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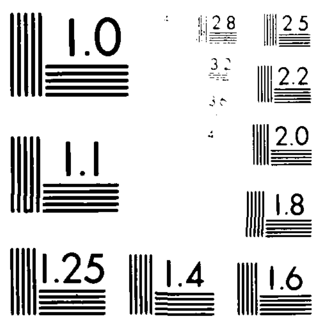

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Monterey, California

THESIS

HOW GOVERNMENTAL POLICIES REGARDING STRATEGIC
AND CRITICAL MATERIALS AFFECT THE
ACQUISITION OF MAJOR WEAPON SYSTEMS

BY

Terry L. Bollman

September 1981

Thesis Advisor: M. L. Sneiderman

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How Governmental Policies Regarding Strategic and Critical Materials Affect the Acquisition of Major Weapon Systems

by

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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

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ABSTRACT

The proliferation of uncoordinated governmental agencies and policies have had dramatic and stifling effects on U. S. strategic and critical materials industries and thus have contributed significantly to current problems of increased prices, lengthening leadtimes, and tenuous availability of these materials. These effects have a direct correlation to the same problems associated with the acquisition of major weapon systems. Government and private industry have been working to improve the situation, but much more needs to be done. A national strategic and critical materials policy must be adopted and implemented by a singly responsible agency; inventory goals of the National Defense Stockpile must be filled; and an investigation of an "economic stockpile" should be undertaken.

TABLE OF CONTENTS

I. INTRODUCTION

A. GENERAL

There has been evolving over the past several years a growing concern about the ability of the United States defense industrial base to produce in a timely manner the major weapon systems needed to maintain a strong defense capability. One of the vital aspects of this ability is the ready availability of strategic and critical raw materials at reasonable prices.

It is the objective of this thesis to determine what effects past, present, and proposed government policies, regulations, laws, and agencies have on the availability and price of strategic and critical materials and, consequently, on the acquisition of major weapon systems. To be addressed will be past and present government policies and the current status of the various aspects related to the strategic and critical materials industries in this country. Through the simultaneous investigation of these two areas an attempt will be made to satisfactorily answer the central research question: "How do government policies regarding strategic and critical materials affect the acquisition of major weapon systems?"

Secondary research questions to be answered are:

1. How do strategic and critical materials impact the manufacture of major weapon systems?

2. What is the current status of U. S. strategic and critical materials reserves and production?

3. What are the current government policies regarding strategic and critical materials?

4. How have government policies affected the strategic and critical materials industries?

5. What is being done to improve the strategic and critical materials situation?

B. SCOPE AND ASSUMPTIONS

The scope of this effort is limited to an investigation of the effects that availability and price of strategic and critical materials have on the acquisition of major weapon systems. To be presented will be the current status of U. S. reserves and production of these materials, government policies regarding the materials, the involvement and activities of private industry, and current initiatives and recommendations directed at improving the strategic and critical materials situation. There will be no attempt at a technical explanation regarding the chemical nature of strategic and critical materials nor at any description of the workings of the related industries.

It is assumed that the reader has some familiarity with the field of strategic and critical materials and of their uses in major weapon systems.

C. METHODOLOGY

Primary research material was collected through a comprehensive search of the literature base for applicable

studies and articles. Information was obtained from the library of the Naval Postgraduate School, the Defense Logistics Information Center, the Office of Legislative Affairs (Navy Section), and various private corporations.

Secondary research material was collected via discussions with government officials and members of private companies involved with managing strategic and critical materials.

Telephone and personal interviews with almost a dozen private companies provided invaluable insight into the problems and initiatives currently affecting the industry. Likewise, personal interviews with Mr. Paul Butler, Office of Industrial Mobilization, Department of Commerce and the following Federal Emergency Management Agency personnel--Mr. Paul Krueger, Director, Office of Plans and Preparedness; Ms. Carmel Cassidy, Executive Assistant to the Director of the Office of Plans and Preparedness; and Mr. Bob Mroczek, Acting Chief, National Defense Stockpile Policy Division--provided valuable inside information regarding the problems facing the government and rare insight into "why" certain actions are taken.

D. ORGANIZATION OF THE STUDY

Chapter II is intended to give the reader some background into what strategic and critical materials are and how they are used in the production of major weapon systems.

Chapter III describes the current status of U. S. position regarding strategic and critical materials and the growing dependence on foreign sources of supply. The concept of the National Defense Stockpile is introduced and further elaborated. And, lastly, prevailing prices and leadtimes are investigated.

The themes of Chapters IV and V are similar in that they both are devoted to current policies, initiatives, and recommendations regarding strategic and critical materials--Chapter IV from the government perspective and Chapter V from that of private industry.

Chapters VI and VII are the Analysis, and Conclusions and Recommendations, respectively.

II. BACKGROUND

A. STRATEGIC AND CRITICAL MATERIALS AS ELEMENTS OF THE DEFENSE INDUSTRIAL BASE

Over the past several years there has been much discussion about and many studies initiated on the United States' deteriorating defense industrial base.

The report of the Defense Industrial Base Panel of the Committee on Armed Services, House of Representatives, Ninety-Sixth Congress entitled "The Ailing Defense Industrial Base: Unready for Crisis" is indicative of this nation's growing concern over this deterioration and the consequent decrease in the capability to produce, in a timely manner, the weapon systems necessary to maintain the necessary level of defense.

One of the several specific areas of concern addressed and found to be disturbing by members of the above panel is that the shortage of strategic and critical materials, combined with the resulting dependence on uncertain foreign sources for these materials, is endangering the very foundation of our defense capabilities.[5:1]

General Alton D. Slay, at that time Commander, Air Force Systems Command, strongly reiterated the above finding in his statement before the Industrial Preparedness Panel of the House Armed Services Committee in November 1980.[28:III-18]

Said he: "...it is abundantly clear to me that shortages of critical materials and our dependence on foreign sources for many of them are two of our most critical defense industrial base problems. There are other financial, productivity, and quality issues which I will discuss in the balance of this statement. But without an adequate and dependable resource base, solutions to these problems will be of little help in solving the total industrial base problem."

B. WHAT ARE STRATEGIC AND CRITICAL MATERIALS?

1. Strategic and Critical Materials Defined

For purposes of this research, strategic and critical materials will be defined as those designated as such in the National Defense Stockpile Inventory published semi-annually by the Federal Emergency Management Agency (FEMA). [9:14-18] As can be discerned from Table 1, Appendix A, there are presently ninety three (93) individual materials listed in the Inventory. Some of these individual materials are consolidated into Family Groups. This grouping results in a net total of sixty one (61) individual materials and family groups. More information regarding why some materials are listed in different forms within family groups will be presented later in this thesis.

2. Who Determines Which Materials Are Designated Strategic and Critical?

The Strategic and Critical Materials Stockpiling Act of 1979 (50 U.S.C. 98 et. seq.) makes the President of the United States responsible for determining "...from

time to time...which materials are strategic and critical materials..."[9:21] By Executive Order 12155 of 10 September 1979, the President transferred the above responsibility to the Director of the Federal Emergency Management Agency. The Office of Plans and Preparedness was established within FEMA to carry out the mandate.[9:2]

The Office of Plans and Preparedness determines which materials will be stockpiled and what inventory goal level will be established for each based on an intricate econometric model whose input information is received from the Departments of State, Defense, Interior, and Commerce and from historical consumption data from 109 U. S. industries. Revisions to the goals are effected periodically.[12:2-10]

C. KEY EXAMPLES

As was stated previously and as is shown in Table 1, Appendix A, there are 93 individual materials designated as strategic. Throughout the remainder of this thesis, statements will be made which generalize about all these individual materials as a whole and how they as a single entity affect the acquisition of major weapon systems. However, because there will be instances in which specific, individualized facts and figures will be necessary for emphasis and explanation, three minerals have been selected from the group to be representative of strategic materials in general. These three minerals are chromium, cobalt, and titanium.

Each of these three was selected for different individual reasons which will be reviewed later; but, in general, the three were selected because they have been included in a group of "five minerals that put together are the metallurgical Achilles' heel of our civilization." [17:68] The other two members of this group are manganese and the platinum group metals. The selection of these three minerals is not an endorsement that they are any more important or critical than any other strategic minerals. The findings and recommendations that will be presented in this thesis are applicable to all the strategic materials and not just to chromium, cobalt, and titanium.

1. Chromium

Chromium in economic quantities is produced from its primary ore chromite. Although the United States has some currently known chromite resources--in the Stillwater Complex in Montana and in the beach sands of Oregon--because mining it has been economically unjustifiable, there has been no chromite mining conducted in this country since 1961. [11:297-299]

World resources total about 36 billion short tons of shipping-grade chromite, sufficient to meet conceivable world demand for centuries. Over 99% of these resources are in southern Africa--nearly 25 billion short tons in the Republic of South Africa and over 11 billion short tons in

Zimbabwe. [3:32] Annual United States consumption in 1980 was 1.04 million short tons.

Chromium is used for a variety of purposes such as decorative trim for automobiles and other items and for use in chemical processing equipment. But the one use most crucial to defense systems is that of making stainless steel.

The qualities of corrosion retardation and wear resistance imparted to stainless steel through the use of chromium make this common alloy essential to the production of weapon systems.

Because of the significant cost increases and the detrimental effects on performance associated with using other minerals in place of chromium, there is, for all practical purposes, no substitute for this critical mineral.

2. Cobalt

Cobalt is recovered as a byproduct of mining both copper and nickel. The United States does have some cobalt resources accessible to mining located in the Midwest and the Far West. However, the low grade of these resources makes mining them economically unfeasible. Domestic mine production ceased in 1971.

Identified world resources of cobalt total about 6 million short tons of which the largest concentration of the highest grade ore is in southern continental Africa in the Katanga Province of Zaire. In addition to these

identified sources, the world's hypothetical and speculative resources of cobalt contained in manganese nodules on the deep sea floor (the typical nodule contains 0.3 percent cobalt) and in lateritic iron-nickel deposits of tropical regions amount to millions of additional tons. Annual United States consumption in 1980 was 8,800 short tons.[3:36]

Cobalt is basically used in the production of superalloys. It imparts to these superalloys essential qualities of heat resistance, noncorrosive high strength, wear resistance, and superior magnetic properties.[7:10]

Modest rates of substitution of nickel for cobalt can be achieved. As a general rule, however, significant substitution of nickel for cobalt cannot occur without compromising the performance or lifespan of the product. Nickel does not approach cobalt in thermal shock resistance or resistance to oxidation or corrosion. Chromium, manganese, aluminum, iron, nickel, tungsten, and platinum can substitute, at least partially, for cobalt magnets. However, as can be seen from Table 1, Appendix A, with the exception of iron, the United States is also extensively import dependent for these materials.[7:15]

3. <u>Titanium</u>

To arrive at its end-use form, titanium undergoes a two-step refinement process. First, titanium sponge, a porous metal which is not useful in this form, is processed

from the raw minerals rutile and ilmenite. The titanium sponge then undergoes a melting process which yields titanium metal.

Rutile is mined from deposits of certain kinds of sands. Although the yield of rutile is small, there are ample world supplies of these sand deposits. Identified world resources total about 280 million short tons of contained rutile. Brazil accounts for the largest portion at 100 million short tons. Australia has 10 million short tons and the United States 2 million. Annual United States consumption of rutile in 1980 was 250,000 short tons. [3:130]

Ilmenite is also mined from sand deposits. Because of the low-grade yield qualities of ilmenite, once recovered, 98% of the mineral is used to produce titanium dioxide which is used in the titanium pigment industry for purposes other than producing titanium metal. There have now been developed, however, processes which upgrade the ilmenite to a form comparable to rutile. World resources of ilmenite total about one billion short tons of which 54 million are within the United States. Annual United States consumption of ilmenite in 1980 was 1.03 million short tons. [3:70]

According to figures compiled by Timet Inc., one of three major domestic titanium processors, the world contains resources sufficient to supply titanium consumption for 300 years; and North America and Australia possess 70% of these resources.

Titanium metal is low in density, light in weight, exceptionally strong, and resistant to many forms of corrosion. Alloys have been developed which have the strength of steel at 60% the density. These alloys can be used at temperatures far exceeding 1,000 degrees Fahrenheit. Because of this special property, titanium alloys are the most engineeringly efficient materials of construction for critical parts of both defense and commercial airframes and the power plants used to propel them. Currently, about two-thirds of all titanium mill product shipments are allocated to the aerospace industry. [32:1-2]

For aircraft and space vehicles manufacturing uses there is essentially no viable substitute for titanium metal. For industrial uses high-nickel steel, and to a limited extent, the superalloy metals may be substituted. [3:169]

D. HOW DO STRATEGIC AND CRITICAL MATERIALS AFFECT THE ACQUISITION OF MAJOR WEAPONS SYSTEMS?

A general starting point toward answering the above question is an appreciation of the indispensable role nonfuel minerals play in our society. There is not an aspect of America's large diverse economy that is not dependent upon nonfuel minerals. The technologic creativity that has set this country apart from the rest of the world

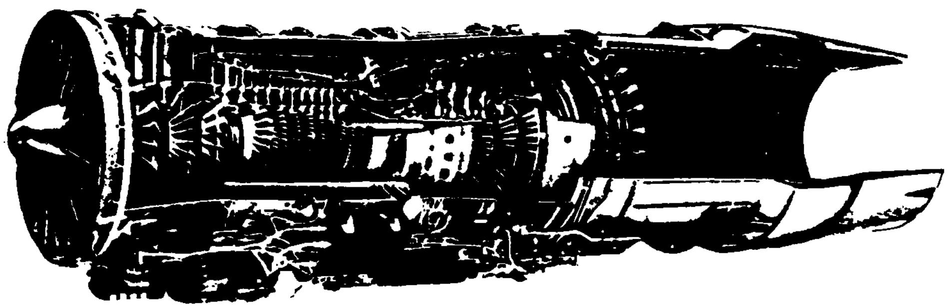
has been its innovative use of nonfuel minerals and energy to produce faster and better. Notwithstanding that irrefutable fact, few Americans today realize that significance--that all of what they do depends upon minerals--and that without adequate and reasonably priced supplies, the economy would grind to a halt. A modern defense capability depends upon the certain availability of large quantities of special metals and alloys.[32:vii]

Nonfuel (strategic and critical) minerals are essential to a strong defense capability due to their uses in virtually all defense equipment and supplies. The following paragraphs will illustrate just how prolific and critical are those uses.

1. Uses of Strategic and Critical Materials in Defense Systems

Virtually every mineral and even some of the nonmineral materials listed in Table 1, Appendix A, are used in the manufacture of defense systems. Figure 1, which shows the magnitude of the amounts of seven strategic minerals used in the F-100 jet engine, is illustrative of these uses. [33:79] The F-100 engine is currently used on the F-15 and F-16 Air Force Fighters.

MINERAL REQUIREMENTS FOR THE F 100 TURBOFAN FIGHTER ENGINE



Mineral Requirements

Metal	Pounds	U.S. 1979 dependence on foreign supplies, percent
Titanium	5366	100 (primary raw material)
Nickel	5204	77
Chromium	1656	90
Cobalt	910	90
Aluminum	720	10
Columbium	171	100
Tantalum	3	96

FIGURE 1

Although all the minerals used in defense systems are equally essential, in keeping with the previously stated policy of concentrating on chromium, cobalt, and titanium, the remaining illustrations of uses will be restricted to those three minerals.

2. Uses of Chromium

In addition to the use in jet engines illustrated in Figure 1, chromium is critical to the manufacture of intercontinental ballistic missiles, cruise and tactical missiles, tanks and infantry fighting vehicles, and naval surface ships and submarines.[9:9]

William J. Perry, former Undersecretary of Defense for Research and Engineering, recently told Congress that the proposed MX strategic intercontinental ballistic missile system would require 2,500 tons of chromium to build. [10:45]

3. Uses of Cobalt

The amount of cobalt necessary to jet engine manufacture as shown in Figure 1, is used to make superalloys which are subjected to stress at high temperatures. These superalloys are used to make the turbine blades and discs, the stator vanes, and the supercharger buckets and afterburners on all the following military jet aircraft engines--F-100, JT-9, JT-10, RB-211, TF-404, TF-700, CF-650, CF-606, and CFM-56.

In addition to the applications on the engines, cobalt is critical to other components of the aircraft such as motors and generators, precision rotation equipment, relays, transformers, fasteners, landing gear components, high strength bolts, torque transmission trains, propellant cases, engine hangar mounts, and tail sections. In turn, the above engines and components directly affect the manufacture of virtually every high-performance aircraft in the U. S. defense arsenal, e.g. the F-18, the F-16, and the F-15.

Cobalt is also critical to the manufacture of the following military applications:

a. Helicopter engines, fasteners, flange bolts, and structural components.

b. Missile components, cases, hardware, and springs for Trident, Poseidon, Harpoon, and Dragon missiles.

c. Military tank and precision rotating components and cannon recoil springs for the M-60 tank.

d. Armor piercing projectiles and parts.

e. Rocket engine cases and warheads.

f. Inertial navigation equipment.

g. Propulsion systems (fossil and nuclear).

h. Missile control parts and cases.[7:12-15]

4. <u>Uses of Titanium</u>

Currently, the most common military applications for titanium, by far, are uses in jet engines, airframes,

and missiles. A small quantity is used in certain valves and piping onboard submarines.

Presently there are studies being conducted on the feasibility of using titanium in the construction of submarine pressure hulls. Projections for the amount of titanium required for each submarine hull and other components range from 1,000 short tons to approximately 1230 short tons. [36:3-4]

In the same statement to Congress mentioned previously, Mr. Perry reported that the MX missile system would require 150 short tons of titanium. [10:45]

E. SUMMARY

The growing number of investigations which have been spawned by increasing concern over the deterioration of the nation's defense industrial base have revealed as one of the causes of this demise to be the shortages of adequate supplies of strategic and critical materials.

Strategic and critical materials play an indispensable role in our everyday lives and are absolutely essential to the maintenance of a strong defense capability. Virtually every strategic mineral--specifically chromium, cobalt, and titanium--is critical to the manufacture of the United States' strategic and tactical weapons systems.

III. STRATEGIC AND CRITICAL MATERIALS CONCERNS

A. INTRODUCTION

As was stated in the previous chapter, production of the United States' defense arsenal is dependent upon the availability of strategic materials. This fact by itself should generate no real cause for alarm because there are ample world resources of these materials to satisfy world demand for many years. In fact, the U. S. Bureau of Mines' detailed supply and demand forecasts to the year 2000 show that world reserves of most mineral materials should be adequate to meet world demands over the next two decades and that for many minerals the United States itself is in a favorable position.[21:3]

The facts, however, that mineral production in the United States has been decreasing over the past several decades and that this nation is now, consequently, no longer self-sufficient in this area and is growing more dependent on foreign sources for critical materials are reasons for people of this nation to become more concerned.

General Slay expressed his growing concern to the Defense Industrial Base Panel in this way...

> "There was a time when we produced more raw materials than we consumed. Since 1950, however, our raw materials situation has deteriorated drastically. We have now become dangerously vulnerable to the OPEC

> type mineral cartels. The dangers of a high dependence on foreign sources for any item essential to our nation's survival can best be illustrated by the OPEC oil cartel which caused: price escalation, shortages, inflation, dollar devaluation, trade deficits, and economic stagnation. While oil is the best known and the most important single commodity subject to possible cartel-type actions, it is not the only one...Much of the world's production and reserves of a number of our critical materials are located in two areas of the world: Siberia and Southern Africa."[5:25]

The cartel-type actions mentioned above have, in the past, been invoked by other nations for economic reasons--to upgrade domestic standards of living and to enhance world recognition. These economic cartels can have devastating results on other world economies as previously noted about OPEC. These effects remain, however, economic.

Notwithstanding the seriousness of the above effects, what the people of the United States should be most seriously concerned about are the political implications of this nation's growing dependence on foreign minerals sources and the opportunities this increasing vulnerability presents to our potential adversaries.

> "The Soviet Union has been operating on parallel tracks in its efforts to establish a position of superiority over the Western alliance. One has been the breakneck expansion of Russia's war machine. Another has been the systematic effort to deprive the West of automatic access to its sources of fuel and cheap raw materials." [22:422]

The above excerpt is a description of Plan Azev. It came from a fictitious novel entitled <u>The Spike</u>, and though there is no place in a thesis for speculation based on fictitious

supposition, the question is just how fictitious is the foundation of information which spawned the passage.

The following passage forms part of that foundation:

> "Our aim is to gain control of the two great treasure houses on which the West depends: The energy treasure house of the Persian Gulf and the mineral treasure house of Central and South Africa." [28:III-7]

This quotation is not fictitious. It was uttered by Leonid Breshnev to Siad Barre, President of Somalia, in Prague in 1973.

Have the Soviets taken any steps since 1973 to accomplish Mr. Breshnev's aim? Regarding "the mineral treasure house of Central and South Africa," it appears as if they have.

Significantly, they have been moving into Third World projects to fill the vacuum created by the withdrawal of Western mining consortia. In the past several years the Russians have negotiated, either on their own or through CMEA, the Eastern bloc Council of Mutual Economic Assistance, 27 technical-and economic-assistance agreements with Third World countries that produce strategic minerals or have deposits. The agreements vary, but in general they feature large-scale Soviet technical aid for exploration and development of new mines, with eventual payment in the form of recovered minerals.

Meanwhile, the Russians and their allies are gaining military footholds in places where they could one day cut off Western access to strategic minerals.[18:44]

Looking at a map of Africa (Figure 2) it is apparent that the countries containing vast reserves of strategic minerals are precisely those in and around which Russian, East German, and Cuban military personnel are stationed.

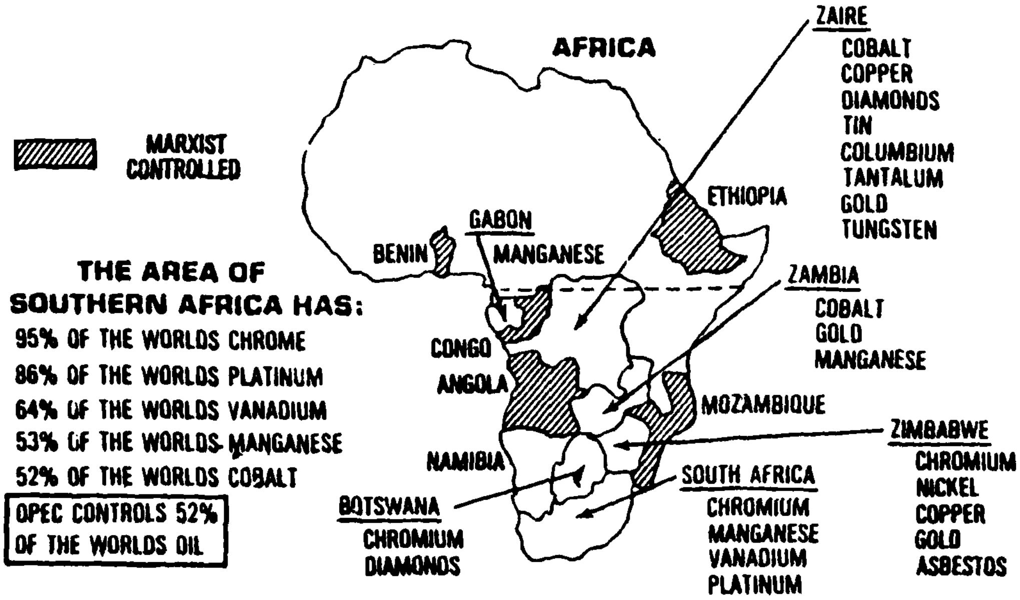


FIGURE 2. THE PERSIAN GULF OF MINERALS

The remainder of this chapter will focus on some specific aspects of this serious situation.

B. UNITED STATES DEPENDENCE ON FOREIGN SOURCES

1. General

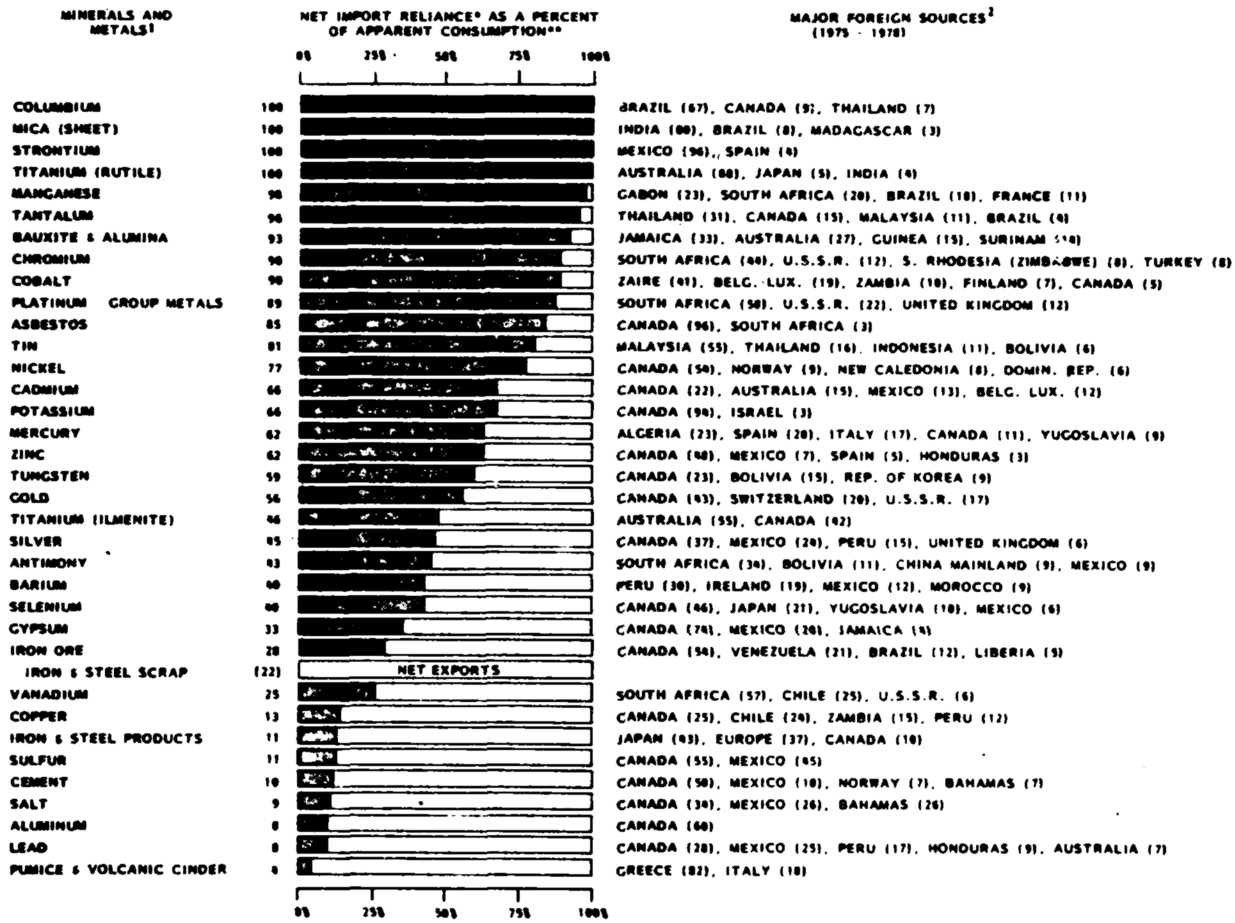
The United States economy gobbles up over $140 billion worth of metals per year. In 1978, imports were only $10 billion of that total, a 30 percent increase over the 1977

import total.[24:46] The 1979 import figure was $25 billion. Even though a portion of these increases can be attributed to world inflation, the ultimate result is that the United States is becoming increasingly import dependent for its minerals. One government study warns that by the year 2000, the U. S. mineral trade deficit will approach $100 billion in current dollars.[24:46]

The United States is more than 50 percent dependent on foreign sources for over half of the 35 minerals shown in Figure 3 which have been described as most essential to our $2.3 trillion economy. [28:III-1]

Much of the world's production and reserves of a number of these critical materials are located in two areas of the world: Siberia and southern Africa. These two areas contain 99 percent of the world's reserves of platinum group metals; 80 percent of the world's manganese ore; 97 percent of the world's vanadium; 96 percent of the world's chromium; 87 percent of the world's diamonds; 60 percent of the world's vermiculite; and 50 percent of the world's fluorspar, iron ore, asbestos, and uranium. Zaire and Zambia now provide 65 percent of the world's cobalt.[28:III-3]

The strategic implications for the United States of these geographical concentrations of minerals are obvious. The developing nations of southern Africa are economically and politically unstable. The possibility of an unpredicted, rapid disruption of significant supplies of the above minerals



*NET IMPORT RELIANCE = IMPORTS-EXPORTS
*ADJUSTMENTS FOR GOVT AND INDUSTRY STOCK CHANGES.
**APPARENT CONSUMPTION = U.S. PRIMARY
*SECONDARY PRODUCTION + NET IMPORT RELIANCE

APRIL 1980

[1] SUBSTANTIAL QUANTITIES ARE IMPORTED FOR FLUORSPAR. GRAPHITE RHENIUM AND ZIRCON. DATA WITHHELD TO AVOID DISCLOSING COMPANY PROPRIETARY DATA.

[2] SOURCES SHOWN ARE POINTS OF SHIPMENT TO THE U.S. AND ARE NOT NECESSARILY THE INITIAL SOURCES OF THE MATERIAL

BUREAU OF MINES, U.S. DEPARTMENT OF THE INTERIOR (IMPORT EXPORT DATA FROM BUREAU OF THE CENSUS)

FIGURE 3 U. S. NET IMPORT RELIANCE OF SELECTED MINERALS AND METALS AS A PERCENT OF CONSUMPTION IN 1979

is always present. The presence of Marxist regimes in several of these nations, as shown in Figure 2, is also a continuous threat to the supply pipeline to the West. And if, for whatever reason, the African supply were severed, the chief remaining source would be the Soviet Union.

2. Chromium, Cobalt, and Titanium

a. Chromium

U.S. Bureau of Mines statistics indicate that the United States is 91 percent import dependent for chromium, and the remaining 9 percent of supply comes from recycled scrap, not domestic mineral supplies since the United States currently produces no chromium. [3:32] It is interesting to note that jet engine manufacturing needs for chromium cannot be satisfied from commercial scrap because of purity requirements. Therefore, for this vital use, the United States is 100 percent import dependent for chromium.

Chromium is imported in two forms. In 1980, 990,000 short tons of chromite, which typically contains 22 percent to 38 percent chromium, were imported from the Republic of South Africa (40%), the Philippines (15%), U.S.S.R (16%), Turkey (10%), and other sources (19%). Also last year 350,000 short tons of ferrochromium, which typically contains 36 percent to 70 percent chromium, were imported from the Republic of South Africa (62%), Yugoslavia (11%), Zimbabwe (9%), Japan (5%), and other sources (13%). [3:32]

Although there are several sources listed above, it must be noted that together, Russia, Zimbabwe, and the Republic of South Africa control more than 80 percent of world chromium production. [24:51]

Also of significance is the fact that for years the Soviet Union has been a major supplier of chrome ore to the West. Shipments, however, have dropped by 50 percent beginning in 1978.

There are, currently, conflictly opinions as to the motive behind this action by the Russians. Some leading American businessmen speculate that the Soviet Union has hit on a new, immensely effective technique for crippling Western industrial production by cutting off supplies of strategic minerals. Others feel that depletion of identified Russian reserves plus difficulties encountered in efforts to discover new domestic sources have caused the Russians to cut back on exports. [18:43-44] Whatever the reason, reduction of the Russian source has made the acquisition of chromium more difficult.

b. Cobalt

According to the U. S. Bureau of Mines, in 1980, the United States was 93 percent import-dependent for cobalt, and the remaining 7 percent of supply came from recycled scrap. There has been no domestic mining of cobalt since 1971.

In 1980, 8,000 short tons of cobalt were imported from Zaire (42%), Belgium-Luxembourg (16%), Zambia (13%), Finland (6%), and other sources (23%). [3:36] It must be noted that Belgium and Luxembourg have no domestic cobalt mines. Their sources for raw cobalt are mainly Zaire and Zambia.

Over the years, supply of cobalt has been highly uncertain. During the Angolan civil war in 1976, supplies were interrupted when the rail line that carries cobalt from the mines in Zaire, Zambia, and Botswana to the Angolan port city of Lobito was cut. Major supplies of cobalt were again severed in 1978 when rebel attacks in the Shaba Province, the key cobalt mining region in Zaire, caused the mines to close. [7:8-9] The political situation in southern Africa is still highly volatile, and there remains only one rail line on which to ship cobalt to the rest of the world.

Due to the high world market price of cobalt brought about by the 1978 shortage, the extensive, but low-grade, concentrations of domestic cobalt are currently being explored for possible economically feasible extraction.

c. Titanium

The United States imports both ilmenite and rutile--the raw materials used to manufacture titanium products. It also imports titanium sponge metal which, as mentioned previously, is the result of the first manufacturing process toward making titanium finished metal.

In 1979, the United States was 100 percent import-dependent for rutile. The 1980 figure was not released to the public in order to avoid disclosing industry proprietary data. It is known, however, that 235,000 short tons of the mineral were imported by the United States from Australia (84%), India (5%), and other sources (11%). [3:130]

Net import reliance data for titanium sponge metal has never been released by the U. S. Bureau of Mines, again because of sensitive industry proprietary data. Imports for 1980 amounted to 4,500 short tons which came from Japan (72%), U.S.S.R. (21%), United Kingdom (6%), and China (1%). [3:168]

The difficulty facing the United States regarding titanium is not that it is import dependent on unstable sources. As can be seen from the statistics above, the United States receives the large majority of its rutile from Australia. The shortage in titanium occurs because there is less than sufficient domestic capacity to process the rutile into sponge. This fact forces the United States into also importing foreign processed sponge.

As with chromium, the Soviet Union has recently withdrawn from the titanium sponge supply market. This loss of supply, which, as previously discussed, the United States depended on for over one fifth of its imports of sponge, greatly intensified the shortage of sponge in the domestic market during 1979 and 1980. [16:57]

To ease the current shortfall in sponge producing capacity and also to alleviate the import dependence to some extent, the U. S. titanium industry is expanding capacity. Predictions are that the shortage of titanium will be overcome by the end of this year. [16:57]

There has also been developed a process by which ilmenite can be upgraded to a quality equal to rutile for making sponge. The United States possesses about 54 million short tons of ilmenite, over 5 percent of the total world reserves. According to industry officials, however, it would take 4-5 years to bring on-line a plant to produce titanium sponge from ilmenite. [16:59]

C. U. S. VERSUS U.S.S.R.

As can be seen from the above information, the United States is sorely dependent on other nations for satisfaction of its needs for strategic minerals. Because of the technological complexities of a modern society, it is hardly possible that any nation can be self-sufficient in all minerals required to totally support its economy. There is one nation, however, which apparently has had the foresight to create natural minerals and resource strategies to assure adequate supplies. That nation is the Soviet Union. Today, the U.S.S.R. is virtually self-sufficient for most of its minerals needs. Russia is to some degree import-dependent for only five minerals. These five are tin, bauxite/alumina, flourine,

antimony, and tungsten. In only one of the five--bauxite/ alumina-- are they more than 50 percent import dependent. Additionally, the Soviet Union is a major producer and exporter of platinum group metals, chromium, manganese, nickel, and titanium ore. [28:III-4] As was mentioned earlier, these exports, however, are no longer going to nations of the West.

Simon D. Strauss, director and former vice chairman of Asarco, Inc., a mining, smelting, and refining company, summarized the contrasting U. S. and Soviet positions in regard to minerals policies in the following manner: [31:53-54]

- The Soviet Union emphasizes mineral self-sufficiency. The United States has taken no steps toward improving its position in self-sufficiency and seems to disregard this as a matter of national priority.

- The Soviet Union restricts consumption of minerals if necessary to avoid import deficiencies. The United States as a consumer economy places no limitations on consumption other than to suggest the desirability of increased recycling.

- The Soviet Union is a major exporter of minerals and uses mineral exports to obtain foreign currency. The United States imports of minerals are steadily increasing. The net effect of this has been to add to the pressures weakening the U. S. dollar.

- Soviet policy in Africa strongly serves Soviet commercial interests since turmoil in Africa will strengthen the prices of Soviet exports. U. S. policy in Africa is dictated entirely by political considerations. In fact, the Rhodesian (Zimbabwe) embargo has been commercially disadvantageous to the United States.

- While the Soviet Union expresses sentiments of interest in the Third World, it has in fact not materially assisted developing countries in expansion of their mineral industries. The United States has made capital available on favorable terms and has extended trade concessions.

- Exploitation of Soviet mineral deposits is in no way inhibited by environmental considerations. In the United States the proliferation of environmental and safety regulations puts a heavy burden of capital and operating costs on the mineral industries. In some instances these regulations are forcing marginal producers to suspend operations. Private groups are permitted, and indeed encouraged by the government, to delay and hinder mineral development through litigation.

D. NATIONAL DEFENSE STOCKPILE

1. History and Purpose of the Stockpile

The need to have some resources of certain commodities readily available in case of a crisis was recognized as early as 1939. The Strategic Materials Act was passed in June 1939. It provided for the purchase of only a very few mineral commodities.

During World War II, the diversion of manpower and shipping to procure strategic minerals and materials was of such magnitude that, following the war, the Stockpiling Act of 1946 was passed. This Act enlarged the number of commodities covered by the 1939 law and provided for the establishment of stockpiles to ensure supplies of essential minerals in the event of a future war.

The intensification of the cold war and the Korean War resulted in passage of the Defense Production Act of 1950 which, among other provisions, created a second stockpile--the Defense Production Act Inventory.

A third separate stockpile--the Supplemental Stockpile--was established in 1954 by the Agricultural Trade Development and Assistance Act. Its purpose was to receive foreign minerals commodities bartered for U. S. agricultural products

The above stockpiles were each originally maintained by different agencies. Use of the commodities in each stockpile was governed by different regulations. And yet each stockpile contained duplicates of commodities held by the other two. [11:195]

These three separate stockpiles were eventually combined into the National Defense Stockpile (hereafter to be referred to as the Stockpile) by enactment of the Strategic and Critical Materials Stockpiling Act of 1979.

As stated in the Act, the purposes of the Stockpile are (1) to serve the interest of national defense only and not to be used for economic or budgetary purposes, and (2) to provide stockpiled quantities of materials sufficient to sustain the United States for a period of not less than three years in the event of a national emergency. [9:21]

In addition to the formal purposes stated above, it is intended that the Stockpile will reduce leadtimes and

demands on manpower, energy, production capacity, scarce machinery, and transportation incident to mining and processing that would otherwise create additional demands in a war time environment. [5:29]

The responsibilities for determining which commodities, and in what amounts, are held in the Stockpile were passed by the President to the Federal Emergency Management Agency (FEMA) by Executive Order 12155. The Office of Plans and Preparedness was established within FEMA to carry out these responsibilities. [9:i]

Executive Order 12155 delegated to the Administrator of the General Services Administration the Stockpile management functions of storage, inspection, maintenance, security, acquisition, disposal, and market analyses. The Federal Property Resources Service within GSA has been given responsibility for these functions. [9:9]

Stockpile inventory goals are established periodically by the Office of National Defense Stockpile Policy within the Office of Plans and Preparedness. An elaborate econometric model is used to formulate these goals. The model incorporates, among other factors, projected uses of strategic materials during a national emergency as forecasted by the Department of Defense; a summation of separate sets of estimated requirements for each sector of a three-tier economy--defense, essential civilian, and general

civilian; historical 12-20 year strategic materials consumption data for 109 U. S. industries provided by the Commerce Department; supply information and import dependence statistics from the Department of the Interior; political reliability factoring of foreign supply sources which reflects the accessibility of those sources in time of emergency obtained from the State Department; and special factors such as an evaluation of domestic processing capacity for a material to determine if the material should be stockpiled in ore form or an upgraded, processed form. [12:2-10]

In addition to establishing stockpile goals, the Office of Plans and Preparedness is responsible for coordinating any restructuring of the Stockpile through the Annual Materials Plan. Each year an Annual Materials Plan (AMP) is utilized to restructure, if necessary, the current list of strategic and critical materials. The AMP is a list of materials proposed for acquisition and disposal developed through an interagency committee chaired by FEMA. The agencies represented on the Annual Materials Plan Steering Committee are the Departments of State, Treasury, Defense, Interior, and Commerce, the General Services Administration, and the Office of Management and Budget.

The Departments of Defense, State, and Comme and FEMA all chair subcommittees which investigate various probable ramifications resulting from the restructuring of the materials list. A more detailed examination of what

aspects these subcommittees investigate will be presented later in this thesis.

After the recommendations from the subcommittees have been incorporated, the AMP is reviewed by all member agencies. Upon inclusion of approved revisions, the Director of FEMA submits the AMP to the National Security Council and simultaneously provides a copy to the Office of Management and Budget. Any further revisions are made jointly by the National Security Council, the Office of Management and Budget, and FEMA. [9:3-4]

2. Status of the Stockpile

a. General

As shown in Appendix A, there are 93 strategic materials (61 Family Groups) stockpiled in the National Defense Stockpile. Market value of these inventories is approximately $14.9 billion. The commodities are stored at 116 different locations throughout the United States

- 34 military depots.
- 28 General Services Administration depots.
- 16 other government-owned sites.
- 10 leased commercial sites.
- 28 industrial plant sites.

These sites are as diverse as the William Langer Jewel Bearing Plant, Rolla, North Dakota, where jewel bearings are stored, and Citibank, New York, where industrial diamonds are stored.

As shown in Figure 4, stockpiles of over 60 percent of the strategic materials do not meet established goals. Over 37 percent, or 23 materials, are less than 50 percent of goal. [9:3]

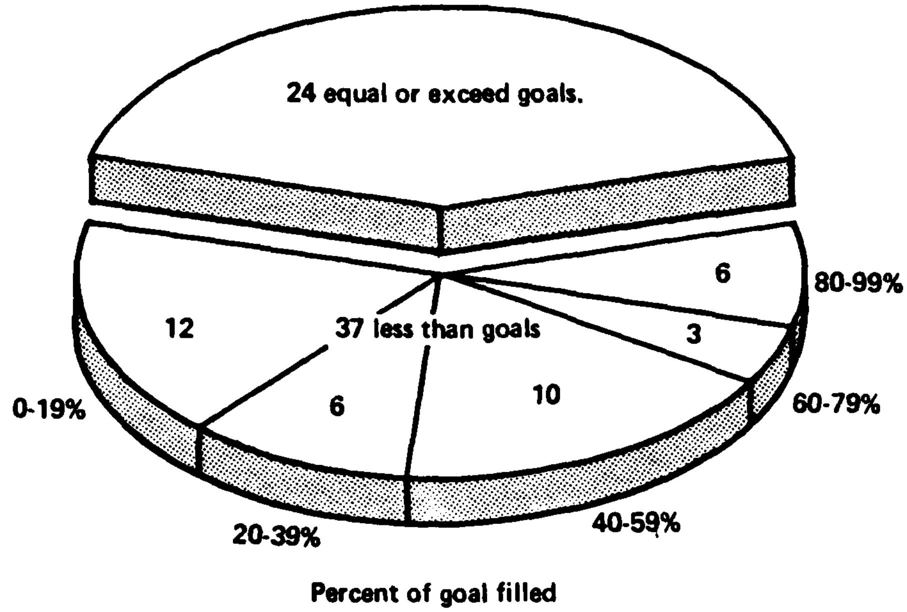


FIGURE 4

The Federal Emergency Management Agency reports that $12.6 billion of purchases would be required to fill the Stockpile goals. [9:2]

Quality of the materials stored in the Stockpile is also a concern. Much of the materials remaining today was purchased for or transferred to the Stockpile during the 1950's shortly after enactment of the 1946 Stockpiling Act. [9:2] There has not been a major Stockpile purchase made since 1960. [28:III-14]

The forms in which materials are kept in the Stockpile are also being questioned by both industry personnel and government officials. Mr. Robin Brumwell, Executive Vice President of Cabot Mineral Resources, a leading producer of superalloys, states, "Form is as important as quantity. There is little point in emphasizing chromite in a stockpile when the country's ability to convert to ferrochrome is extremely limited." [2:3]

The Defense Industrial Base Panel believes that as a matter of prudence, many materials need to be converted from the ore state to the primary metal or alloy. Through these conversions, energy is stored and the materials are then readily available for use without further processing. [5:29]

b. Chromium, Cobalt, and Titanium

Chromium is listed in the Stockpile, Appendix A, as a Family Group. The summary line, "Chromium, Chemical and Metallurgical Group," shows that chromium falls 179,770 short tons shy of the established goal. The goal is almost 87 percent met.

The Stockpile inventory for cobalt is in excess of 44 million pounds short of the 85 million pound goal. The goal is less than 48 percent filled.

There are currently only 32,331 tons of titanium sponge in the Stockpile. Of this total, 10,836 tons are

considered not to be of stockpile grade. Therefore, the goal of 195,000 tons has only been 11 percent attained.

E. LEADTIMES AND PRICES FOR CHROMIUM, COBALT, AND TITANIUM

The primary research area of this thesis is the question of how strategic materials affect the acquisition of major weapons systems. This section will show how prices and leadtimes to acquire both the raw materials and the initial products into which they are formed have increased dramatically over the past several years. It will also be shown how these increases have consequently caused equally dramatic extensions in delivery times and rises in prices for major weapons systems.

Increases in prices and increases in leadtimes each causes its own unique problems. With limited money resources available in the Department of Defense budget, price increases result in the affordability of fewer units of the weapon system being bought or an equal number of units of less costly, lower performance weapons. Increased leadtimes result in the weapon system entering the defense arsenal at a later date than anticipated. In today's high technology, rapidly changing defense arena, these delays result in weapons, which are already obsolete in terms of the threat they attempt to counter, being added to the arsenal.

The price of chromite ore rose over 50 percent in 1977--from $39 per metric ton to $59 per metric ton. Since that

time, however, the price has stabilized and currently remains at $55 per ton. [3:32]

Until 1978, the price of cobalt hovered around the $4.00 - $7.00 per pound range. The shortage of cobalt in 1978 resulting from the rebel-caused disruption of supply from Zaire pushed the price of cobalt up to an average of $25.00 per pound. [7:4] The price on the spot market, driven by a 70% allocation of supply to users, soared as high as $50.00 per pound. [26:1] Even though supplies have returned to normal and allocations have been lifted, the price has remained at $25.00 in spite of the fact that this arbitrary level far exceeds costs of production.

Since 1976, the price of titanium sponge has increased from $2.70 per pound to $7.02 per pound--an increase of 160 percent. In 1980 alone the price increased by almost 77 percent. [3:168]

The above price increases, as well as increases in the prices of other strategic materials such as nickel (65%), columbite ore (250%), and tantalum ore (300%), all contribute to the soaring costs of major weapons systems. The price rise in cobalt alone, for example, caused price increases for the F-100 engine of almost $18,000; the J-79 engine, $21,000; and the TF-34 engine, $21,000. [28:III-15] All the above engines are used on military aircraft.

The increase in leadtimes associated with strategic materials is a somewhat more complex issue than that of the

increases in prices. There are numerous reasons why lead-times have increased. Two of the more important ones are raw materials shortages and inadequate production capacity resulting in large backlogs in specialty metals fabrication.

When all levels of manufacturing from acquiring raw materials to processing finished metal to delivering finished weapons are viewed as a whole, the titanium industry exemplifies the leadtime problems associated with the strategic metals industry in general.

As mentioned earlier, the supply of rutile is plentiful, relatively secure, and presents no leadtime problem. Lack of processing capacity for turning rutile into titanium sponge is, however, creating increased leadtimes. In 1976, average leadtime for sponge was 40 weeks. In 1980, that time had increased to 104 weeks. The second step in the process--manufacturing forgings and extrusions--is an industry also fraught with insufficient capacity. Large titanium forgings, which were delivered in 70 weeks in 1978, took 180 weeks in 1980. Delivery schedules for extrusions during this same period increased from 65 weeks to 108 weeks. Small, but absolutely critical items, such as titanium bolts and fasteners underwent delivery time changes of 32 to 62 weeks and 25 to 58 weeks, respectively. [25:30-32]

The end result of the above increases is that components used on major weapons systems, and thus the weapons systems themselves, are delayed in entering the defense arsenal.

From 1977 to 1980, the delivery time for aircraft landing gears, which are made from titanium, grew from 52 weeks to 120 weeks. Delivery schedules for the F-100 engine have increased from 19 to 41 months. [5:13] The TF-34 engine, which was delivered in 1977 in an average 20 months, now takes 39 months to be received. [25:32] Leadtime for the F-15 aircraft has increased by 22 percent; F-16's by 50 percent; and A-10's by 34 percent. [28:III-17]

Increasing emphasis on uses for strategic materials outside the defense arena in such programs as improvement of energy supplies and utilization, coal gasification, coal liquefaction, magnetohydrodynamics, nuclear fission, and nuclear fusion can be expected to put even greater demands on all aspects of the strategic materials industries. [21:3-4] These demands could very well press prices higher and leadtimes longer.

F. SUMMARY

There appear to be world reserves of strategic materials sufficient to meet world consumption demands for many years to come. Even though the United States possesses adequate resources of many of these materials, they are not being utilized. Consequently, the United States is becoming increasingly import-dependent on foreign sources, of which most of the major ones are located in the economically and politically unstable area of southern Africa.

Recognizing the importance of these strategic materials and the potential catastrophic consequences of not having adequate supplies in times of national emergency, the Congress has passed several stockpiling acts whose purposes were and are to maintain inventories sufficient to support the defense arsenal should supplies be severed. Current stockpile inventories fall short of the goals set and would require purchases totalling $12.6 billion to attain them.

Prices and availability of vital minerals such as cobalt and chromium are almost completely dependent on geopolitical events in southern Africa. Sources for rutile, used to make titanium, are plentiful and relatively secure. Lack of fabrication capacity, however, has caused large price increases and long leadtimes. Increasing interest in titanium for uses outside the defense industrial base portends of possible further leadtime and price growth.

The following chapter will present evidence which indicates that governmental policies related to matters affecting the strategic and critical materials industries have been the major causes of the problems presented in this chapter.

IV. GOVERNMENTAL POLICIES REGARDING STRATEGIC AND CRITICAL MATERIALS

A. INTRODUCTION

> "Government has the responsibility for the defense of the nation and therefore must be concerned about supplies and availability of mineral raw materials which in the modern age constitute the power to make war. These are the metals to build the machines of war, fuels to operate them, and a host of non-metallic industrial minerals to construct operational and training facilities and to feed the chemical and metallurgical requirements of an industry straining to support the war and the domestic economy. Government has the responsibility for the economic well-being of the country in peace and war." [11:182]

Thus Peter Flawn, Director, Bureau of Economic Geology, The University of Texas, expressed what fundamental precepts should underscore a nation's minerals policy.

As will be substantiated by the following sections of this chapter, the United States lacks an effective national non-fuel minerals policy. There is very little, if any, coordination of activities among the some twenty agencies involved in implementing laws and regulations governing the strategic and critical materials industries. In fact, there is conflict and overlap of responsibilities present among these agencies and also among the laws they implement.

On the positive side, it will be shown that various government officials and agencies have initiated over the past several years efforts to improve the U. S. strategic and critical materials position and to move toward

implementation of a non-fuel minerals policy which meets Flawn's requirements and more.

B. GOVERNMENT STUDIES, LEGISLATION, AND POLICIES AFFECTING STRATEGIC AND CRITICAL MATERIALS

There have been no less than 20 mineral or material policy studies that have been prepared or commissioned by one governmental agency or another, as well as others prepared for groups outside government. [33:ix]

This section will present a chronology of these studies plus all legislation pertaining to strategic and critical materials.

The first national commission to examine the use of the nation's natural resources was President Theodore Roosevelt's National Conservation Commission of 1909, which devoted most of its time to petroleum and high-grade iron ore. World War I highlighted the criticality of certain minerals, other than petroleum and iron ore, to the national defense and prompted the War Department to publish its 1921 so-called Harbord List of 28 minerals found to be in short supply during the war.

Much debate was carried on between the two world wars regarding wartime shortages, strategic stockpiles, and the question of least-cost imports versus self-sufficiency; but very little substantive legislation or study was conducted until 1939 when the Bureau of Mines-Geological Survey study listed 39 critical and strategic minerals. Subsequently,

the original Strategic Minerals Act was passed in 1939 and provided for the purchase of a few minerals. [33:8]

During World War II, the diversion of manpower and shipping to procure strategic mineral materials was of such magnitude that following the war, the Strategic Minerals Act was amended to become the Stockpiling Act of 1946 which directed the establishment of stockpiles to insure supplies of essential minerals in case of a future war. [11:195]

The intensification of the cold war between the East and West and the Korean War prompted the passage of the Defense Production Act of 1950 and also President Truman's appointment of the President's Materials Policy Commission, better known as the Paley Commission after its chairman, William S. Paley.

Title III of the Defense Production Act is the section which had direct impact upon the strategic and critical materials industry. Title III provided for the expansion of productive capacity through loan guarantees and direct government loans. The Act also provided for the encouragement of exploration, development, and mining of minerals and metals; for research and development of substitutes; and for, in effect, the creation of a second stockpile known as the DPA Inventory or Stockpile. [6:2187] The above provisions were funded as necessary via a revolving fund established specifically for the Act. In 1974, the

revolving fund was abolished and a requirement established that each program be submitted to the Congress for appropriation. Since 1974, very few programs have survived the perils of political scrutiny by the Office of Management and Budget and the Congress. [25:62]

The Paley Commission began its investigation just six months after the United States entered the Korean Conflict. The study took eighteen months to complete and produced a five-volume report which is still considered a classic.

The Report recognized that no nation can be totally self-sufficient. In reviewing the complexities of policy issues, the members of the Commission arrived at the conclusion that because many other national goals affect the availability of minerals, it is not possible to spell out in law definitive directions for those responsible for policy implementation. Therefore, at the core of any minerals policy must lie a national understanding of the importance of minerals.

The Paley Commission made sixty-five recommendations. The final two emphasized its strong conclusions regarding government's responsibilities. First, the analytical capability of the government must be strengthened, and second, the dimensions of the issues require direction by a policy group within the Executive Office of the President. [33:9]

As in 1950, 1954 produced both a study report and legislation pertaining to strategic materials. The "Report of the President's Cabinet Committee on Minerals Policy" strongly emphasized government's role in strengthening domestic mineral productivity and the building of strategic and critical stockpiles as a fundamental step toward national security. [33:9-10] The Agricultural Trade Development and Assistance Act established a third stockpile-the Supplemental Stockpile-to receive foreign mineral commodities bartered for U. S. agricultural products. [11:195]

After fifteen years of legislative inaction, in 1970 Congress passed two laws affecting strategic materials-the National Materials Policy Act and the Mining and Minerals Policy Act.

The only consequence of the National Materials Policy Act was the formation of the National Commission on Materials Policy. The Commission's recognition of the importance of domestic development and the role of the private sector, the necessity for access to public lands, and the need for improved technology was buried in its one-sided enthusiasm for conservation and control because of past environmental imbalances. [33:10]

When Congress enacted the Mining and Minerals Policy Act of 1970, after twelve years of effort, it adopted a policy that was thought to provide a means of addressing

not only the changes in reliability of foreign supplies but, more importantly, to establish a national value of domestic production. The Act is, on its face, simply a statement of fundamental principles and objectives that was intended to establish a set of Congressional priorities against which the executive branch is to weigh other objectives and proposed actions. [33:14] The responsibility for carrying out the policy of the Act, which was to foster and encourage private enterprise to improve the domestic mineral industry, was given, by the Act, to the Secretary of the Interior. [25]

On 12 December 1977, President Carter announced the initiation of a cabinet-level Non-fuel Minerals Policy Review in response to a February 1977 letter from 43 members of the House of Representatives expressing deep concern regarding the direction of government policies that were adversely affecting the nation's production of non-fuel minerals, the failure of the Department of the Interior to implement the Mining and Minerals Policy Act of 1970, and the need for a special minerals advisor in the Executive Office of the President. The resulting cabinet-level Policy Coordinating Committee was chaired by the Secretary of the Interior and further composed of the Secretaries of Commerce, State, Treasury, and Energy; Administrators of the Environmental Protection Agency and General Services Administration;

Director of the National Science Foundation; Assistant to the President for National Security Affairs; Chairman of the Council of Economic Advisors; Special Representative for Trade Negotiations; Chairman of the Council of Environmental Quality; Director of the Office of Management and Budget; and Director of the Office of Science and Technology Policy.

The Presidential directive which initiated the Committee also outlined the "serious concerns" for study. They were:

> "Whether the trends toward international interdependence and the politicization of certain minerals markets are increasing U. S. vulnerability to foreign supply curtailments and price manipulations;
>
> Whether U. S. reserves, production capacities, and inventories are adequate to deal with possible supply/price interruptions, or with the economic and social consequences of such disruptions;
>
> Whether land use decisions are based on adequate minerals information and analysis;
>
> Whether current tax laws favor the use of raw minerals over recycled minerals or encourage substitution and other conservation practices;
>
> Whether current government regulations adequately protect the environment, health, and safety while not unduly affecting the supply and price of minerals;
>
> Whether minerals policies adversely affect U. S. trade posture and balance of payments; and
>
> Whether existing government policy analysis, data analysis, and data collection functions are adequate to support federal decisionmakers responsible for formulating, implementing, and monitoring nonfuel minerals policies." [33:23]

Upon submission of the Committee's final report, the House Committee on Interior and Insular Affairs held

hearings at which none of the 42 witnesses who testified considered the report adequate. The House Committee reported, "The entire effort was a tragic waste that cost American taxpayers about $3.5 million and the loss of some 13,000 person days." [33:22-24]

In July 1979, the Stockpiling Act of 1946 was amended and became the Strategic and Critical Materials Stockpiling Act of 1979. This Act was an attempt to improve the management of government stockpiling activities. The National Stockpile, the DPA Stockpile, and the Supplemental Stockpile were consolidated into the National Defense Stockpile. It was emphasized that the purpose of the Stockpile is to "serve the interest of national defense only and is not to be used for economic or budgetary purposes." And, the Act established in the Treasury a separate fund designated the National Defense Stockpile Transaction Fund which would receive all moneys generated from the sale of materials from the Stockpile to be used only for the purchase of other Stockpile materials. [9:21,24]

In 1980, the Congress became distressed over the Department of Interior's decade-long inactivity in developing a national minerals policy as intended by the Mining and Minerals Policy Act of 1970. Consequently, it passed the National Materials and Minerals Policy, Research and Development Act of 1980. This Act directed that the President,

through the Executive Office of the President, coordinate the activities of all agencies assigned responsibilities by the Act. The Act assigned specific implementation responsibilities to the Secretaries of Commerce, Defense, and the Interior; but it also stated that nothing in the Act was to be interpreted as changing any provision of the Mining and Minerals Policy Act of 1970. [23]

In addition to the legislation noted above, laws which restrict and regulate the strategic materials industry are also important when looking at the evolution of minerals policy. Some laws and policies that have had significant impact are the Clean Air Act, the Federal Water Pollution Control Act, the Wilderness Act, the Federal Land Policy and Management Act, the Surface Mining Control and Reclamation Act, the formation of the Environmental Protection Agency and the Occupational Safety and Health Administration, and a foreign policy which imposes sanctions on major foreign suppliers of strategic materials in the name of human rights.

There are some additional studies currently being conducted and legislation pending in the areas of strategic and critical materials. The above laws and studies, however, are what currently form the nation's strategic and critical materials policy.

1. Overlaps, Gaps, and Conflicts

An examination of the above studies and laws reveals that there exist among them some policy conflicts, some overlaps, and some gaps.

Until two years ago when the National Defense Stockpile was formed, there were in existence three separate and distinct stockpiles, each with its own set of operating parameters and each containing materials also stockpiled by the other two. Materials held in the DPA Stockpile could have been used or disposed of under presidential authority as long as they were not sold below the prevailing market price. On the other hand, Congressional action was required to release materials from the National Stockpile or the Supplemental Stockpile unless the President invoked the issues of national defense or obsolescence. [11:195] The existence of three unique stockpiles caused confusion, uncoordinated efforts, and inefficient operations.

Lack of a definitized national non-fuel minerals policy has allowed conflict to arise between proponents of conservation measures and legislation on one side and advocates of minerals exploration and development on the other. The issue is not that each side is unflinchingly opposed to the desires of the other, but that there is no agency or appointed individual in a position to arbitrate the conflicts and balance the pros and cons of each constituency. Consequently, each side continues to push for what it thinks is right, and confrontations continue.

Another example of conflicts between two disparate advocacy groups is that of the needs of the minerals industry

versus U. S. foreign policy. Rep. Santini summarized the disparity in the following way:

> "Our foreign policy has not been in tune with the reality that is shaping the nature of the United States dependency or that of the free world. It is imperative that foreign policy, therefore, emphasize the legitimate economic interests of the United States as a significant element of its national security interests. We must have an economic strategy for our relations with foreign nations that will give higher priority to mineral security aspects of those relations. We cannot wait until we are irrevocably trapped. Our foreign policy must work to reestablish traditional economic concepts under international law. [5:27]

A foreign policy "not in tune with the nature of U. S. dependency" is clearly in evidence when sanctions and embargoes are imposed, in the name of human rights, against South Africa and Rhodesia (Zimbabwe)--two countries vital to supplies of many of our strategic and critical materials.

Even legislation covering strategic and critical materials also appears overlapping and confused. The Mining and Minerals Policy Act of 1970 very definitely assigns full responsibility for matters pertaining to strategic and critical materials to the Secretary of the Interior. Although Section 6 of the National Materials and Minerals Policy, Research and Development Act of 1980 specifically states that nothing in the Act alters any requirements set forth by the 1970 Act, it did assign new responsibilities to two other Cabinet-level departments--Commerce and Defense--and additional responsibilities to Interior. These

new assignments have caused confusion as to which Department is now supposed to have overall minerals-policy authority and responsibility.

There is no question that legislation professing conservation of resources and preservation of the environment is as equally important as that favoring minerals exploration. Nor is there much difficulty recognizing the value of human rights. What is needed, however, is a statutory basis for balancing the values of these different advocacies and for formulating them into a coordinated, unified policy.

C. AGENCIES RESPONSIBILITIES REGARDING STRATEGIC AND CRITICAL MATERIALS

According to General Slay there are 20 different federal agencies administering 80 different laws which directly or indirectly affect the non-fuel minerals industry. [28:III-11]

The agencies that indirectly affect the industry are those not involved with policy-setting decisions or day-to-day operational decisions. This fact, however, does not lessen the influence these agencies exert on decisions and operations. For example, the Environmental Protection Agency and Occupational Safety and Health Administration through regulations and promulgations backed by statute very definitely influence, and often dictate, what decisions will be made by firms in the industry.

Some examples of governmental offices with indirect effect of a lesser degree are (1) the Office of Science and Technology Policy which is responsible for coordinating federal materials research and development and related activities. [23:sect.5(b)] and (2) the Defense Advanced Research Projects Agency which is sponsoring materials substitution research.[26:4]

Focus will now shift to those agencies whose activities directly affect matters related to strategic and critical materials.

Pursuant to Executive Orders 10480 and 11490 under the Defense Production Act, and Executive Order 12155 under the Strategic and Critical Materials Stockpiling Act, the Department of the Interior is responsible for emergency readiness plans and programs for all non-fuel minerals. The Department of the Interior is, in general, responsible for mines, concentrating plants, and refineries, and for the ores, concentrates and other materials treated in such facilities.

The Department of Commerce is responsible for facilities and materials that are further along in the chain of processing and utilization, and it maintains the Defense Materials System to channel materials to defense and defense-related production on defense rated orders.

The Department of the Interior has chartered the chartered the Emergency Minerals Administration to carry out actual operations in the event of a major emergency, and the Emergency Minerals Administration is based upon the Bureau

of Mines, with support as needed from the U. S. Geological Survey and other Department of the Interior units. In emergencies, the Department of the Interior operates under the direction of the Federal Emergency Management Agency, the independent agency created in 1979 to consolidate the emergency planning functions of the government.

The Bureau of Mines, within the Department of the Interior, continuously monitors domestic production, imports, exports, stocks, and consumption of all major non-fuel minerals. Detailed reports are received monthly, quarterly, or annually from domestic mines, smelters, refineries, recyclers, and major users. Monthly import and export data are obtained from the U. S. Customs Service via the Bureau of the Census of the Department of Commerce. Bureau of Mines experts also continuously monitor developments in foreign supply areas. To facilitate coordinated government action in the event of a national emergency, the Bureau in 1975 organized nearly 100 interagency mineral commodity committees. These committees include experts from the Bureau of Mines, the U. S. Geological Survey, and one or more areas of State, Commerce, Defense, CIA, FEMA, GSA, Treasury, U. S. Trade Representative, Council of Economic Advisors, International Trade Commission, Commodity Futures Trading Commission, Council of Wage and Price Stability, and for certain commodities, Agriculture and Transportation. These

committees would be promptly called upon in the event of any emergency.

Under the auspices of the Export Administration Act of 1979 which authorizes the use of export controls to restrict exports detrimental to U. S. national security, the Department of Commerce is charged with monitoring exports and contracts for exports of any nonagricultural commodity "when the volume of such exports in relation to domestic supply contributes, or may contribute, to an increase in domestic prices or a domestic shortage, and such price increase or shortage has, or may have, a serious adverse impact on the economy or any sector thereof."

A worsening supply situation could generate the imposition of a system of priorities, under Title I of the Defense Production Act, in which rated orders would have to be filled first. If, however, priorities proved to be inadequate, they would be followed by a system of allocations, also authorized under Title I. The Bureau of Mines and Department of Commerce would implement priorities and allocations in their respective areas of responsibility.

A serious shortage situation could necessitate recourse to the National Defense Stockpile as authorized in Section 3 of the Stockpiling Act. To release stockpiled materials, FEMA, in consultation with other agencies, would prepare a justification and recommendation for the President's

signature. Upon receipt of the President's authorization, the Office of Stockpile Disposal of GSA would release the material to specified recipients.

In the event the above short-term measures cannot cope with a long-lasting supply disruption, long-term domestic supply expansion programs could be sponsored and funded utilizing Title III of the Defense Production Act. The Bureau of Mines would recommend needed mineral supply expansion programs to FEMA, which would then direct GSA to make the necessary contractual arrangements. [20:9-10]

The Strategic and Critical Materials Stockpiling Act of 1979 statutorily established the National Defense Stockpile. Executive Order 12155 assigned the Act's Section 3 responsibilities to FEMA and Section 6 management functions to GSA.

Pursuant to Section 3 and the Executive Order, FEMA established the National Defense Stockpile Policy Division, within the Resource Preparedness Office, within the Office of Plans and Preparedness to formulate and maintain policies and goals relating to the Stockpile. The Stockpile Policy Division receives support in these functions from the Office of Industrial Mobilization, Department of Commerce.

Pursuant to the Executive Order the General Services Administration assigned to its Federal Property Resources Service the Section 6 activities of storage, inspection,

maintenance, security, acquisition, disposal, and market analysis associated with the stockpile program.

Presidential guidance to FEMA also includes a planning process for restructuring the Stockpile through the Annual Materials Plan (AMP). This planning process is accomplished through the Annual Materials Plan Steering Committee chaired by FEMA. Other agencies represented on the Committee are the Departments of Defense, Commerce, the Interior, State, and Treasury, the Central Intelligence Agency, GSA, and the Office of Management and Budget. The Departments of Defense, State, and Commerce also chair subcommittees which investigate various aspects related to the Stockpile such as defense requirements and the impact of Stockpile purchases and disposals on foreign producers and the domestic market. [9:3]

Section 8 of the Stockpiling Act assigned responsibility to the President for making scientific, technologic, and economic investigations concerning the development, mining, preparation, treatment, and utilization of domestic ores and other mineral substances. The President passed this task to the Department of the Interior via Executive Order 12155.

Notwithstanding the importance of the above agencies and their respective activities, the overriding desire of the Congress for more than the last decade has been to develop the framework for the formulation of a national non-fuel minerals policy.

The first attempt was the passage of the Mining and Minerals Policy Act of 1970. According to the Act, "... it is the continuing policy of the Federal Government in the national interest to foster and encourage private enterprise in..." basically building a strong, well-managed domestic minerals industry through a comprehensive, well-planned, coordinated policy. The responsibility to develop the policy was assigned to the Secretary of the Interior. [19]

In 1980, for reasons which will be enumerated later, Congress passed a second law directed at developing a national non-fuel minerals policy. The National Materials and Minerals Policy, Research and Development Act of 1980 assigned specific responsibilities to four other agencies besides the Department of the Interior.

The President, through the Executive Office of the President, is responsible for coordinating the activities of all other responsible departments and agencies, and for implementing a national non-fuel minerals policy. The Director of the Office of Science and Technology Policy is responsible, through the Federal Coordinating Council for Science, Engineering, and Technology, for coordinating all federal materials research and development and related activities. The Secretary of Commerce, in consultation with FEMA, the Secretary of the Interior, the Secretary of Defense, the Director of the CIA, and such other members of the Cabinet as may be appropriate is responsible for

initiating a case study on an industry affected by the availability of strategic and critical materials. The National Bureau of Standards was tasked by Commerce to carry out this responsibility. The Secretary of Defense is to prepare a report to Congress assessing critical materials needs related to national security and identifying the steps necessary to meet those needs. And lastly, the Secretary of the Interior is to initiate actions to enhance the capabilities of the Bureau of Mines and to collect, evaluate, and analyze information concerning mineral occurence, production, and use from industry, academia, and other government agencies.

Section 6 of the Act states very specifically that nothing in the Act was to be interpreted as changing any provisions and requirements of the Mining and Minerals Policy Act of 1970. [23] This section, therefore, reaffirms the responsibility of the Secretary of the Interior to develop a national non-fuel minerals policy.

Upon taking office, President Reagan appointed a Cabinet Council on Natural Resources and the Environment. This Council is looking at all aspects of the use of natural resources verses environmental conservation. No results have as yet been forthcoming, but there should be some emerging in the near future.

1. <u>Overlaps, Gaps, and Conflicts</u>

With the plethora of agencies cited above involved in so many different activities associated with strategic and critical materials, it is inevitable that confusion and conflicts and overlaps will occur.

For example, under the Stockpiling Act via Executive Order 12155, the Department of the Interior is made responsible for conducting research to better utilize domestic reserves of minerals. And yet the R&D Act of 1980 assigns overall responsibility for research and development to the Office of Science and Technology Policy. And although FEMA chairs the Annual Materials Plans Steering Committee, the Agency has no statutory authority to arbitrate disputes and conflicts of interest arising from the different perspectives of the members of the Committee.

The above overlaps and conflicts are basically procedural in nature and could quite easily be remedied. A basic conflict of interests, however, exists between the group of regulatory agencies such as the Environmental Protection Agency whose purpose for being is to conserve and preserve the natural resources and environment, and that group such as the Bureau of Mines whose charter is to improve utilization of domestic minerals resources.

There is no reason to question the validity and importance of each of these purposes. The conflicts between the two groups, however, result in serious consequences

and derive from the one major gap in the area of agencies responsibilities--there is no one agency discharging the responsibility of coordinating and directing the various activities of the numerous agencies. In Congress, for instance, jurisdiction of interstate and foreign commerce, public lands, mining, minerals, procurement laws, defense production, research and development, and taxation is divided among several committees. And within the Executive Branch responsibility is divided among the Departments of Defense, Commerce, the Interior, Treasury, Energy, State, and various other agencies. [5:48]

The House of Representatives Committee on Banking and Currency summed up the situation this way:

> "The problem of scattered and overlapping jurisdictions has increased both in the executive and legislative branches. Such fragmented jurisdiction over the natural resource area maximizes bureaucratic competition and jealousy, while at the same time inhibiting unified policy formulation and implementation. Since natural resource and commodity decisions involve domestic economic and political considerations as well as foreign economic and political policies, a true national perspective must transcend the interests of a particular agency. Still, each agency's information and policy input tends to be directed by a concern for its own clientele rather than a broad consideration of the national interest."[33:28]

This lack of a "national perspective" has not developed from lack of tasking. The intention of Congress in the passage of the Mining and Minerals Policy Act of 1970 was to assign the Department of the Interior the responsibility

for developing a national minerals policy and thus coordinating all activities associated with strategic and critical materials.

According to Representative Santini's Subcommittee on Mines and Mining, notwithstanding the clarity of the statutory language of the Act and the fundamental purpose of its accompanying legislative history, the Department of the Interior has chosen, for a full decade, to abdicate its assigned role and responsibility. It has regarded the mining and minerals industry with a long history of benign neglect. [33:16]

In defense of his Department, the Secretary of the Interior under President Carter declared:

> "The Act does not provide to the Secretary of the Interior any authority or supervisory responsibilities over other Federal Departments as they exercise their authorities in carrying out responsibilities which affect minerals policy." [33:17]

There thus exists a fundamental disparity between interpretations of the Act by the principals involved.

Over the past four years, the General Accounting Office has investigated implementation of the 1970 Act and has, among other aspects, stated that it is the "basic responsibility of the Secretary of the Interior to identify requirements for achieving a coherent national policy regarding non-fuel minerals." [33:20]

According to conversations held by this researcher with the Office of Plans and Preparedness within FEMA and with the Office of Industrial Mobilization within the Department of Commerce, the perceived abdication of responsibility by the Department of the Interior prompted the passage of the National Materials and Minerals Policy, R&D Act of 1980. The intent was to spread responsibilities among other agencies in hopes of generating new efforts toward formulating a national policy.

These same conversations revealed that instead of enhancing efforts toward developing a national policy, passage of the Act has caused more confusion. The National Bureau of Standards was tasked by the Department of Commerce to coordinate and carry out its portion of the Act. When questioned on who was in charge of formulating a national non-fuel minerals policy during testimony before Senator Harrison Schmitt's Subcommittee on Science, Technology, and Space, the Director of the Bureau of Standards was unable to respond. Secretary of the Interior Watt and Secretary of Commerce Baldridge have both indicated that their respective departments now have taken the initiative to formulate a policy.

President Reagan has shown his apparent preference on which agency should be in charge by placing Secretary Watt as chairman of the Cabinet Council on Natural Resources

and the Environment. And in the opinion of Mr. Paul Krueger, Director of the Office of Plans and Preparedness, Congress will wait to see what evolves from this Council before taking any further action.

D. CURRENT NATIONAL DEFENSE STOCKPILE POLICY

In general, past management of the National Defense Stockpile has been subjected to a great deal of criticism, with the lion's share falling upon the General Services Administration. GSA has in many cases, however, only been an instrument used and abused by other governmental agencies.

One area severely censured has been use of the Stockpile, in conflict with the purpose as stated in the Stockpiling Act of 1946, as a means to help balance the federal budget. GSA correspondence shows that many of the sales in the early to mid-1970's were indeed conducted under pressure from the White House and Congress in order to balance the budget. These sales amounted to an average rate of $700 million per year from 1970 to 1975, with a peak of $2 billion in 1974. Other GSA documents suggest that in 1971, the Office of Management and Budget had already included revenue of $103.2 million in its next budget in anticipation of the sale of surplus nickel. [34:A1]

The passage of the new Stockpiling Act of 1979 was thought to have ended the use of the Stockpile for budgetary purposes. Section 3 states specifically that the Stockpile

is to be used for purposes of national defense only and Section 9 establishes the Transaction Fund whose funds, generated from sales of stockpiled materials, can only be used to purchase additional stockpile materials. What appears solid on paper, however, sometimes proves to be full of holes in operation. According to information obtained from interviews with personnel from the Federal Emergency Management Agency, funds brought into the Transaction Fund through sales must be authorized and appropriated by Congress for use within three fiscal years following the end of the fiscal year in which they are received. If they are not appropriated within this period, the funds are transferred to miscellaneous receipts of the Treasury. Appropriation must, like all other funds, come from Congress via the President. Theoretically, therefore, Congress or the President could use funds from the sale of strategic materials to balance the budget by merely failing to authorize and appropriate their use.

There is currently a resolution in the House of Representatives which restricts the sale of strategic materials to $500 million per year. The intent is to make the Transaction Fund a less lucrative source for balancing the budget.

The Government has also been cited for using its resources in the Stockpile to influence the market of raw materials. As an example, in November 1965, the Government,

in a determined attempt to prevent aluminum and copper price increases, threatened immediate and massive Stockpile sales of these metals. [11:199]

But in general the most severe criticism has been directed at the apparent mismanagement of the Stockpile and related activities. Internal GSA auditors have charged that over the last decade tens of millions of dollars have been lost through the sales of surplus materials at below market prices. In self-defense, GSA personnel who negotiated the sales contracts said that without generous terms, the agency would not have been able to sell surplus stocks at all. [34:A1]

An illustration of management at its worst is that used regarding the cobalt stockpile. At one time the stockpile contained 102 million pounds, but decisions to reduce the goal caused a substantial share to be declared excess.

As a consequence, 60 million pounds were sold between 1964 and 1975. At that time no problem existed regarding cobalt production or world supplies. Yet, these stockpile sales doubtless contributed to holding down cobalt prices, thus annoying the government of Zaire--the world's major producer--and discouraging potential producers of by-product cobalt from investing in projects to recover the metal. In 1976, when the government substantially increased the stockpile goal to 85.4 million pounds, stockpile sales stopped, but by then the inventory was down 40.8 million pounds. With the invasion of Zaire in 1978, the market

tightened and prices skyrocketed. However, at that time the Stockpile was no longer in a position to sell. Today, the United States has a stockpile which is 48 percent of its goal, and a dependency on southern Africa for 76 percent of its requirements, and cobalt priced at $25 per pound. Although criticism based on hindsight is always easy, it would appear that the United States must share a large part of the responsibility for cobalt's present chaotic market conditions.

The current Republican Administration appears to have a much more keen interest, than did the last, in the status of the Stockpile. This interest was manifested early in this new administration by President Reagan's announcement in March 1981 of authorization and appropriation to buy $100 million worth of strategic materials--the first major buy since 1961.

This renewed enthusiasm will hopefully reverberate throughout the agencies involved with the Stockpile and generate a clear-cut purpose for its use.

E. GOVERNMENTAL INITIATIVES AND RECOMMENDATIONS

From the preceding sections of this chapter it would seem that the government is wallowing in a quagmire of shortsightedness and mismanagement regarding strategic and critical materials. While there are definitely some difficulties to overcome, the government is by no means

lacking for activity in this area. The following paragraphs will prove that much time and effort, especially in the recent past, have been expended in an introspective look at current laws, policies, and regulations. This self-investigation has resulted in initiatives directed at improving the situation and recommendations on what further needs to be done.

1. <u>Initiatives to Improve Government Actions and Policies</u>

Representative Santini has remarked that "...with the exception of the Paley Commission in the 1950's under President Truman, (the members of government) have not taken a good look at our minerals policy." [14:53]

Up until just a couple of years ago, that statement was true. Since 1979, however, an increasing number of investigations into policies and regulations affecting strategic and critical materials have been conducted. The following is a brief synopsis of some of the major ones.

As Chairman of the Senate Subcommittee on Science, Technology, and Space, Senator Harrison Schmitt (New Mexico) held hearings and concluded that, "Recent U. S. foreign policy has created a chain of events which, if they proceed unchecked, will result in direct or indirect Soviet control of these sources of supply." He outlined a six-point program calling for development of mineral reserves in this country and focusing foreign policy more sharply on national goals. [14:51]

Throughout the 96th Congress, the Mines and Mining Subcommittee chaired by Rep. Santini (Nevada) conducted a lengthy and detailed inquiry into the availability of essential minerals. The resultant report stressed that many problems exist, from inefficient utilization of public lands for minerals exploration to antiquated antitrust laws, and made several recommendations for improvement--some of which will be detailed later in this section. Rep. Santini stressed that although the problems are many and diverse, they funnel down to one conclusion--the United States is promoting its dependence upon foreign sources at the very time the security of many of those sources is becoming less certain. [33:vii]

The Defense Industrial Base Panel of the Committee on Armed Services, House of Representatives also conducted hearings during the Ninety-Sixth Congress. The Defense Industrial Base Panel was formed as a direct result of the disturbing findings of the 1980 Summer Defense Science Board on Industrial Responsiveness, appointed by the Undersecretary of Defense for Research and Engineering. Although the Panel's charter was to investigate the larger area of the defense industrial base, it did include an inquiry into the area of strategic and critical materials. Its conclusion--a shortage of critical materials, combined with a resulting dependence on uncertain foreign sources, is endangering the very foundation of our defense capabilities. [5:1]

Upon his entering office, President Reagan demonstrated his concern in this area by appointing the Cabinet Council on Natural Resources and the Environment which is to look at the strategic materials national policy, or lack thereof. Also under his direction, the National Security Council is investigating the effects of a cobalt shortfall.

In addition to the above rhetoric being exchanged and the reports being generated, initiatives in other areas are also being undertaken.

Research and development efforts in several different areas have been quite prevalent. Most of the efforts are being conducted under sponsorship by FEMA and the Department of the Interior through the Bureau of Mines; however, other agencies are also involved.

The Departments of the Interior, Commerce, and Defense and FEMA are jointly sponsoring various National Academy of Sciences studies on strategic minerals. One study is evaluating the advantages of upgrading stockpiled materials to shorten emergency production leadtimes. The study focuses on balancing the need for versatility of application allowed by stockpiling as raw ore versus the desirability of shorter production leadtimes resulting from holding upgraded forms. Other studies are developing methods for assessing substitutability of non-fuel materials. [9:4]

Research in the Bureau of Mines includes development of new mining and processing technology, recycling methods,

and improved materials for better performance. Under study are several methods for recovering chromium, nickel, and cobalt from laterite deposits and also from flue dusts, plating wastes, and other residues. Special emphasis is being placed on methods affecting chromium. To help develop recovery techniques for scrap, a pilot plant has been designed to treat superalloy scrap containing chromium as well as other critical materials. Other conservation approaches include surface chemistry research using ion implantation. This method would produce a corrosion and wear-resistant layer having properties of a high-chromium alloy, while the bulk of the material would contain little chromium. [9:5] [21:2]

The U. S. Geological Survey conducts a broad-ranging non-fuel mineral exploration program to assess new domestic sources of mineral raw materials. The "Stillwater Complex" in southwestern Montana is currently being studied. This complex has greater potential for the production of platinum and chromium than any other place in the conterminous United States. The complex also has potential for development of copper, cobalt, and nickel. [9:6]

Bureau of Mines scientists are evaluating rare-earth cobalt magnets in which 20 percent of the cobalt has been replaced by a mixture of copper, iron, and magnesium. Permanent magnets represent one of the largest uses of

cobalt, accounting for about 20 percent of total U. S. consumption. [9:7]

As a hedge against possible shortages and cost escalations, the Department of Defense is preparing a substitute materials R&D program. Possible substitute options have been identified for beryllium, titanium, cobalt, and chromium.

The only feasible substitutes for beryllium may be metal-matrix composite materials which DOD estimates will require five years and approximately $34 million to develop.

Although graphite-epoxy and graphite-polymide composites can be substituted in some structural applications of titanium, the most realistic group of substitutes is again from the metal-matrix composites family. Fiber-reinforced titanium composites substituted for the bulk metal result in savings of titanium metal and improved specific stiffness. Savings of titanium are estimated at 50 percent.

Basic research and development programs are evaluating a discontinuously reinforced titanium composite material. When high surface temperatures for short durations are found as in advanced tactical missile structures, a 90 to 100 percent savings of titanium can be achieved by substituting aluminum matrix composites with surface claddings of titanium or nickel foil. Feasibilty of this clad composite concept has been demonstrated. Another possibility for high

temperature applications would be the substitution of graphite-reinforced copper. While the specific strength at low temperature for the reinforced copper is far less than titanium, it is expected that at high temperatures, its specific strength and stiffness will exceed that of titanium. According to DOD estimates, a five-year program costing approximately $100 million would be required to explore and develop these options and provide substitutes for titanium. [9:8-9]

Rapid solidification rate (RSR) technology, being conducted by the Pratt and Whitney Company under the sponsorship of the Defense Advanced Research Projects Agency and the Air Force, may alleviate the extensive defense uses of chromium and cobalt. Continuing research is being conducted on this process which can produce nickel alloy mixtures hertofore unknown in the form of an ultrafine powder. These alloys, essentially depleted of chromium and cobalt, are based primarily on other strengthening agents such as molybdenum and aluminum which are more readily available. [9:9]

In seemingly direct response to Senator Schmitt's earlier cited statement about misguided U. S. foreign policy, ever since his election, President Reagan has sounded the theme of a new "constructive" tilt in U. S. relations with strategically important countries, particularly South Africa. This theme appears to be the beginning of a movement away from a foreign policy based on worldwide preservation of

human rights to a more pragmatic one based on national economic and defense interests.

The world's oceans are enormous untapped repositories for a large number of minerals. Aside from hydrocarbons, greatest interest has centered on manganese nodules--deep seabed mineral deposits containing nickel, copper, cobalt, and manganese--which lie virtually uncovered on the ocean floor, anywhere from 1000 feet to 20,000 feet beneath the ocean surface. An estimate for the total quantity of nodules lying on the Pacific seabed alone is 1.66 trillion metric tons. Based on projections that by 1980 manganese nodule mining would have reached a volume of between 13 million and 17 million dry tons per annum, seabed mining would have contributed the following percentages to world production: cobalt---55%; manganese--48%; nickel--23%; plus small percentages of copper, vanadium, zinc, and molybdenum. [3:various]

Unfortunately, no nodule mining was performed in 1980. The major obstacle preventing such mining is that the nodules are located in international ocean areas in which no state has clearly defined rights (or prohibitions against) mineral exploitation.

At the behest of the United States, in 1972, the United Nations chartered the United Nations Conference on Law of the Sea to agree on an acceptable arrangement for mutual benefit from deep seabed mining. In August 1980,

the Ninth Session of the Third Conference was held in Geneva. No final treaty emerged. In anticipation of such a treaty, however, the United States government has already passed into law the Deep Seabed Hard Mineral Resources Act which authorizes U. S. companies to begin commercial mining after 1 January 1988. [13:121] Most estimates agree that it will be 1990 at the earliest before the oceans play a major supply role.

The last two major areas of initiatives are directed at improving the position of the National Defense Stockpile and at better utilization of the Defense Production Act(DPA). They are looked at together because better utilization of the DPA will improve the status of the Stockpile.

FEMA has proposed the introduction of a guaranteed purchase program for cobalt under authority of Title III of the DPA. Under this program the government would guarantee to purchase a maximum of 41 million pounds of cobalt at a fixed purchase price below current market price during an eight-year program life. Any cobalt purchased by the government would be held in the Stockpile against the 45 million pounds of outstanding required purchases at a lower cost than is currently feasible. This program would result in development of a domestic source for cobalt which, in turn, reduces import dependence and vulnerability and in acceleration of the achievement of the Stockpile goal by at least 10 years at less cost. [7:7-9,32]

FEMA has also proposed such a guaranteed purchase program, with virtually the same attendant benefits, for titanium as part of a request to Congress for a $3 billion borrowing authority against Title III of the DPA. Consent to this authority would eliminate the appropriation requirement imposed on Title III in 1974. Additional projects proposed for using the $3 billion line of credit are opening one or two cobalt mines and conducting additional substitute materials research.

Outside the use of the Defense Production Act, the government has undertaken recent steps to improve the status of the National Defense Stockpile. $100 million has been appropriated for the purchase of cobalt and other Stockpile materials--the first major purchase since 1961. An additional $100 million has been included in the FY1982 budget request. Legislation is also pending in the House which would eleiminate the requirement for appropriation authority to use funds from the Transaction Fund.

2. Recommendations

In addition to current initiatives, different government agencies have also made recommendations, such as those which follow, that have not as yet come to fruition.

Secretary of the Interior Watt has urged more exploration for minerals on federal lands stating that the best answer to long-term minerals availability is domestic production. [30:61] At the current buying pace, rebuilding

the Stockpile will not be completed until the year 2041; whereas establishing a domestic source cuts the stockpile goal for a mineral by 3 units for every 1 unit of annual production.

In virtually all of his statements and subcommittee reports, Rep. Santini's overriding recommendation is for a coordinated national non-fuel minerals policy developed and administered by one central authority. His National Minerals Security Bill of 1981 [H.R. 3364] proposes both. Section 201(a) proposes a Council on Minerals and Materials composed of three presidentially appointed members who shall have vested in them all responsibilities, with commensurate authority, for administering national policy and for championing the cause for responsible minerals production and consumption. [35:4-5]

As previously mentioned, Mr. Krueger feels the bill has no chance of passing because Congress is awaiting the outcome of the Cabinet Council's research and study.

Various government agencies and officials including Deputy Secretary of Defense Carlucci; former Commander, Air Force Systems Command, Gen. Alton Slay; and members of the Defense Industrial Base Panel have been increasingly trumpeting the benefits of multiyear contracting. Although there are currently some statutory obstacles precluding full use of multiyear contracting, the perceived benefits of

early purchase of long-lead critical materials, the stabilization of defense-related procurements, and the estimated annual cost savings of 10 to 15 percent all increase the desires to utilize multiyear to the fullest. [5:34]

Former Undersecretary of Defense for Research and Engineering William J. Perry proposed a "more imaginative" policy for the Stockpile, using it not only in emergencies, but to ease long-lead problems associated with defense production. [29:55] This researcher has dubbed this proposal the "economic stockpile," a term to be used again in the course of this thesis. Interviews with members of FEMA have revealed that agency to be less than enthusiastic about taking on responsibility for this type of stockpile.

Other recommendations which have been set forth are (1) tax relief for mining and minerals industries, (2) accelerated depreciation for capital assets, (3) revision or easing of antitrust statutes, and (4) a more realistic approach by regulatory agencies.

F. SUMMARY

The investigation of this country's non-fuel minerals status did not commence with any fervor until after World War I, the event which marked the United States' first experience with shortages. Many studies and laws and policies have since been generated causing the involvement of a host of different government agencies.

There exist among these documents, policies, and agencies many instances of overlapping authority, jurisdictional disputes, confusion, and conflicts. Each agency is conducting its operations according to its honest interpretations of the chartering legislation. The problems cited above result from the absence of a unified national non-fuel minerals policy administered by a central coordinating agency or council.

Government agencies and officials have in recent years been initiating various programs and plans whose purposes are to continually improve the strategic and critical materials situation. Furthermore, there are also awaiting action recommendations whose results will provide further benefits.

V. PRIVATE INDUSTRY'S POLICIES AND INVOLVEMENT WITH STRATEGIC AND CRITICAL MATERIALS

A. INTRODUCTION

The previous chapter dealt with governmental policies regarding strategic and critical materials and with what governmental initiatives are being undertaken to alleviate some of the current problems.

This chapter will examine what difficulties industry has encountered in the past and which ones still prevail as a result of some of those government policies. Also to be discussed will be what private industry is doing on its own to overcome some of these burdens.

B. DIFFICULTIES ENCOUNTERED REGARDING STRATEGIC AND CRITICAL MATERIALS

1. Instability of Governmental Policies and Programs

One of the facts revealed by the Defense Industrial Base Panel during their hearings on the defense industrial base was that government procurement programs were too unstable. [5:18]

A group of sub-tier contractors stated this instability was one of the main factors contributing to the failing health of their sector of the industrial base, and that they would much rather do business with the commercial sector because it was much more predictable and stable. [5:13-14]

Weapon system procurement rates are constantly adjusted so that it is virtually impossible for defense industry to do any long-range planning and to effect efficient procurement of long-lead subsystems and components. As an example, of the 47 major defense acquisition programs in effect as of 31 December 1980, 39 had undergone quantity changes (19 increases and 20 decreases) and 41 had experienced schedule changes. [4:13] Notwithstanding the disruptions caused by these changes, the real anxieties afflicting contractors arise from the possibility of programs being terminated completely.

A very good representative example of an industry which has been adversely affected by this instability is the titanium industry. As mentioned in Chapter III, the problems are not in supplies of rutile but in processing rutile into titanium sponge.

Since 1948, when the U. S. titanium industry was born, until the present, titanium demand has been almost solely a product of uses in defense equipment and commercial aircraft. Consequently, the market has been extremely erratic over the last 30-some years.

Because of large anticipated government contracts, a number of companies entered the supply market in the 1950's. A shift in defense strategy and spending in mid-decade from airplanes to missiles, however, caused several

major producers (Dow Chemical, E.I. du Pont de Nemours, and Union Carbide) to withdraw from the field. [37:D4]

The remaining three producers (RMI Company, Oregon Metallurgical Corporation, and Titanium Metals Corporation of America) have twice more been left holding the bag after having expanded production capacity in anticipation of large increases in demand from the aerospace industry--once with the government's decision to abandon development of the supersonic transport and once with the cancellation of the B-1 bomber program [16:57]

With the Reagan Administration's emphasis on defense spending and the possibility of reviving production of the B-1, the titanium industry has already begun expanding capacity. Dow Chemical and Howmet, Inc., for example, are opening a new processing plant. Industry officials, however, are quite wary of the fact that the instability still remains and that the rug may be pulled out from under their feet at any time.

2. Excessive Stifling and Unreasonable Governmental Regulations and Policies

In addition to the instability of government programs mentioned above, there are many government regulations and policies which quite effectively choke off productive efforts by private industry to eliminate or alleviate some of the problems associated with strategic and critical materials. These regulations and policies affect the full

gamut of strategic and critical materials industries from mineral exploration and mining to ore processing to fabrication of end products made from the processed metals.

One obstacle barring the mining industry from making large strides toward eliminating this country's dependence on foreign sources is the government's reluctance to open public lands to minerals exploration and mining. Approximately one-third of the nation's lands, some 750 million acres, is publicly owned. Mining uses less than 6 million acres of public lands. In contrast, farm lands use 1.3 billion acres, highways cover 24 million acres, and airports and railroads cover 6.5 million acres.

In his testimony before the Defense Industrial Base Panel, Rep. Santini voiced his concern by saying:

> "Our Government, over the past 10 years, has made fundamental errors with respect to use or nonuse of public lands for mineral development. Instead, Government policies have proven to be counterproductive and discouraging to the discovery and development of mineral deposits. We have put every conceivable roadblock in the way.
>
> The most deplorable aspect of this shortsightedness about public land use is that it is being done without knowledge of the losses involved. There has been no attempt to understand the long-term impacts. There is no government accountability to weigh the consequences. There have been numerous instances where public lands have been withdrawn when they were known to have mineral potential.
>
> In 1974, one study estimated that we had prohibited or restricted mineral development under the mining law on two-thrids of our public lands.
>
> We hear a lot of "regulatory reform", but all I have seen to date are cosmetic references to that phrase. The most difficult thing for me

> to grasp is that our dedicated but tunnel-vision regulators will be satisfied with nothing short of perfection. They refuse to even consider the alternatives. Perfection becomes a safe refuge in the bureaucratic process. It has created the expectations in the public mind that the only safe standard is "zero risk". [5:27-28]

In addition to restrictions on the use of public lands, the mining industry is beset by many other stifling laws and regulations.

According to General Slay the list of federal restrictions on mineral exploration is extensive. They include land management and land use restrictions such as the Clean Air Act, Federal Water Pollution Control Act, Wilderness Act, Federal Land Policy and Management Act, and the Surface Mining Control and Reclamation Act. [28:III-11]

Currently, there are 80 different laws administered by 20 different federal agencies which directly or indirectly affect the domestic non-fuel minerals industry overall. [5:28] Ones associated with requirements of safety, environment, health, energy, and equal employment have diverted large smounts of business capital from investment in new equipment and facilities.

The Clean Air Act of 1977, for example, has driven up production costs in the metals industry as much as 25 percent without increasing output.

According to industry estimates, the copper industry would have to spend $3 billion by 1985 to meet existing environmental and health and safety regulations. Such a

diversion of funds from investment in productive facilities would result in a 17 percent decline in the domestic output of refined copper.

Because many producers in the lead industry do not have the technology or the money to meet new exposure standards set by the Occupational Safety and Health Administration, they are now shipping 150,000 tons of scrap per year overseas to be processed, a tripling of 1975 export levels. [24:48]

In the past decade, over 400 foundries, which fabricated products using strategic metals, have gone out of business, primarily because of Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) requirements. [25:15]

Another area restrictive and counterproductive to the industry is the inflexibility of government procurement regulations which discourage the use of contract types that would promote the best interests of all concerned. The use of multiyear contracting has been touted as the vehicle to be used to inject stability into defense procurement programs. Widespread use of multiyear contracting, however, has been thwarted by (1) Department of Defense Directive 7200.4 which requires that all units of the weapon system to be procured must be fully funded in the year in which they are to be bought, (2) by Section 810 of the Department of Defense Appropriation Authorization Act of 1976

which imposes a cancellation costs ceiling of $5 million per contract, and (3) by Defense Acquisition Regulation (DAR) section 1-322 which disallows, in case of cancellation, recovery of recurring costs for labor or materials, or other expenses, which might be incurred for performance of subsequent program year requirements. [5:31,34,36]

The 1982 Department of Defense appropriation bill currently being debated in Congress has attached to it an amendment whose purpose is to eliminate at least one of the above obstacles by raising the cancellation ceiling from $5 million to $100 million.

When contracting with the Federal Government, the metals fabrication industry, as well as all other industries, must comply with the Cost Accounting Standards (CAS) promulgated by the now defunct Cost Accounting Standards Board. CAS 409, as incorporated into the Defense Acquisition Regulation, states, "...allowable depreciation shall not exceed the amounts used for book and statement purposes..." [5:44]

The effect of CAS 409 is to require depreciation, used for contract cost purposes, to be based on the historical or economical useful life of capital assets--a much slower rate than that used for income tax purposes. Thus, the contractor must maintain two sets of books--one for government contracting and one for tax purposes. The result is the government absorbs part of the cost of maintaining this

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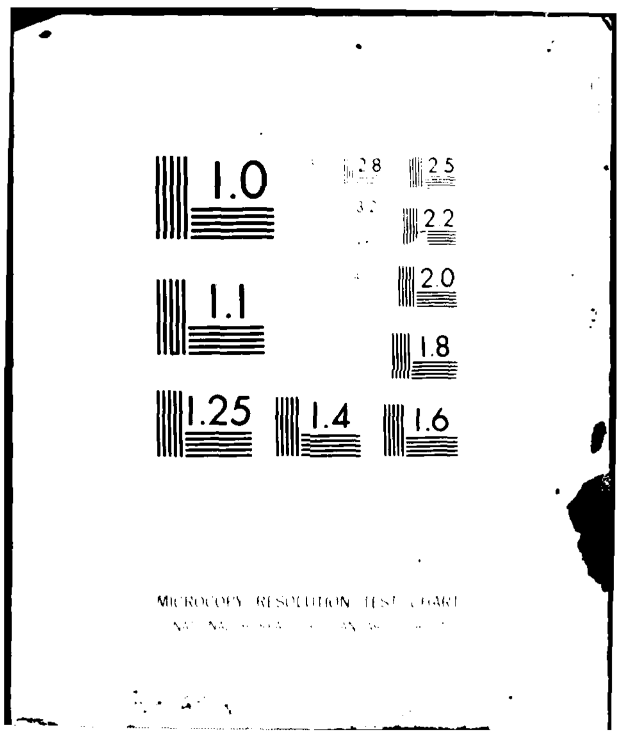
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dual system, and the contractor becomes disgruntled not only because of the dual paper work but also because depreciation must be charged against a government contract at a much lower rate.

Another cost accounting standards requirement directly detrimental to industries dependent on strategic materials is the stipulation that inventories used in performance of government contracts can only be charged to those contracts at a rate equivalent to the purchase cost of those inventories vice one related to current market values. This restriction makes private industry reluctant to stockpile long leadtime strategic materials.

Net results of the above laws and regulations are less productivity, greater dependence on foreign sources for supplies of strategic raw materials, and fewer numbers of contractors willing to do business in the defense industrial base.

C. VIEWS ON GOVERNMENTAL POLICIES AND RECOMMENDATIONS FOR IMPROVEMENT

Via published articles, advertisements, and telephone and personal interviews conducted by this researcher, industrialists associated with the strategic materials industries have opined thoughts that their operating environment is less than optimal due to certain governmental policies. The following sections discuss their most

frequently expressed opinions on laws and regulations and some suggested recommendations on how to improve them.

1. Instability of Government Acquisition Programs

The government must do a better job of deciding earlier what it wants and how many units it needs; and then must only change programs if absolutely necessary. A group of sub-tier contractors intimated to the Defense Industrial Base Panel that because of the risks involved in government programs due to the instability, "...the price difference for performing Government contracts ranged from 25 percent to double the price charged for comparable commercial contracts." [5:14] A greater emphasis on long-range planning is needed to stabilize the Five Year Defense Plan (FYDP), and greater use of multiyear contracting needs to be effected.

2. Multiyear Contracting

According to the Defense Science Board, multiyear contracting could potentially result in cost savings of 10 to 15 percent (in constant dollars). [25:68] Multiyear contracting needs to be utilized to a greater extent. Obstacles to enhanced use need to be eliminated or mitigated. A mechanism needs to be devised by which general full funding can be appropriated in the first year of the multiyear contract so contractors can take advantage of economic-lot-size buys of long-lead strategic raw materials and components which will be used throughout the program life. Department of Defense Directive 7200.4, "Full Funding of DOD Procurement

Programs," requires that each annual appropriation request must contain funds requests to cover the total costs to be incurred in completing the delivery of a given quantity of useable end items. This restrictive direction should be revised to allow procurement of long-lead materials quantities which will be used for more than one year. The cancellation liability ceiling of $5 million on multiyear contracts must be increased. At present this ceiling severely limits the use of multiyear contracting to low dollar value acquisition programs. The Defense Acquisition Regulation section 1-322 which restricts government liability for cancellation costs in case of contract termination to only non-recurring costs should be revised to allow payment for recurring costs such as labor charges, etc.

The unanimous sentiment of the companies interviewed was that much greater use of multiyear contracting was desired and needed.

3. <u>Opening More Public Lands for Minerals Exploration</u>

When expressing their opinions on the question of opening public lands to minerals exploration and mining development, the companies agreed that greater utilization of these lands was needed for the country's benefit. They also expressed, however, that what was sought was not carte blanche access to these lands (they fully appreciate the environmental considerations), but a more realistic,

cooperative approach toward compromising on a trade-off between environmental concerns and economic and defense needs of the nation.

4. Government Regulations and Agencies

Although not expressed as strongly by some as others, the general feeling among the contractors was that the burgeoning amounts of government red tape and regulations were uncalled for and counterproductive.

Stated more emphatically was that the Environmental Protection Agency and the Occupational Safety and Health Administration were unrealistic and inflexible in their requirements. The requirements themselves were also considered unjustified and expensive and were contributing significantly to the production stagnation in the defense industrial base.

5. National Defense Stockpile

There was no disagreement that the National Defense Stockpile was needed. The general consensus was that established goals should be met, and that the stockpiled materials needed upgrading. Notwithstanding this unanimity, several individual recommendations were made. RMI Company suggested that...

> "long term contracts for replenishement and re-building of the Stockpile would be one means to give domestic industry the incentive to go even further in current expansion plans and programs. It would insure both a complete stockpile, and the productive capacity to respond to critical or surge requirements." [32:6]

Timet Inc., one of the three U. S. major titanium processors, recommended that materials be stockpiled more in processed forms vice raw material forms to decrease production leadtime and manufacturing resources required if use of the strategic materials were necessary. Timet also suggested a materials rotation program in which the government would trade or sell materials to industry to preclude obsolescence and deterioration.

6. Economic Stockpile

Because the National Defense Stockpile cannot be used for economic purposes, other means must be developed to smooth out supply and demand fluctuations in times other than national emergencies. Earlier the researcher introduced the term "economic stockpile." The question of should there be an economic stockpile to level out the peaks and valleys of strategic materials supply and demand in times when no national emergency exists was posed to interviewees by the researcher. Because the concept of an economic stockpile has never been attempted, the details of its structure and operation are not as yet available.

In general, however, the economic stockpile would be divorced from the National Defense Stockpile in administration if not physical location, it would be managed by either government personnel or private industrialists depending on guidelines established, and the commodities would be

available for use by government contractors whenever supply shortages warranted.

The opinions were mixed with the yeas and nays being fairly equal. Those who did not favor an economic stockpile said that better long-range planning and strategies would negate the need for an economic stockpile concept, and they favored this long-range thinking to a reactive, stop-gap stockpile.

Of those who favored an economic stockpile, the majority felt the government should not manage it. Peter Flawn, Director, Bureau of Economic Geology, The University of Texas, summarized the majority opinion very well when he wrote:

> "If a materials reserve apart from the strategic stockpile were to be established to operate as an efficient economic stabilizer, it would require continuing purchases to make up for disposition by sales with an acquisitional approval for each transaction. Such a stockpile or materials reserve puts the government in the market place as a buyer and seller of minerals, permits the government to set and control prices, and in short is a further step toward a managed economy." [11:201]

These same opponents to an additional government-run stockpile also stressed that a private-industry-run stockpile would be fraught with problems and potential conflicts of interest and would, therefore, require strict government regulation.

7. Miscellaneous

Several recommendations were proffered by individual contractors, but they failed to receive the degree of consensus or sense of urgency as those already listed. The following is a list of those recommendations.

a. The government should encourage private industry to increase research and development (R&D) efforts toward discovering substitutes for strategic materials. This encouragement could be manifested through tax benefits, or grants, or R&D contracts.

b. There should be established a national minerals policy to guide all involved agencies toward common goals. According to Flawn, "Any mineral policy must concern itself with the health of the domestic industry and its capabilities, foreign mineral trade, national security, and environmental considerations."[11:202]

c. All ramifications of embargoes and sanctions against strategic materials producing countries must be weighed thoroughly before this type of action is taken. The Defense Science Board, for example, iterated that "sanctions on South Africa and Rhodesia are "stupid" considering their effect on our economy and national security." [25:138]

d. Tariffs and export controls need to be implemented in order to assist domestic minerals producers in competing with foreign producers.

e. Use Title III of the Defense Production Act of 1950 to expand the productive capacity of the domestic strategic minerals industry.

D. PRIVATE INDUSTRY'S INTERNAL INITIATIVES

Private industry has by no means been expending all its efforts in criticism of the government's policies and programs, or lack thereof. They have engaged in an ample

number of internal initiatives directed at solving some of the problems confronting them.

As an example of the magnitude of the desire to improve the strategic materials situation, in May 1980, several hundred concerned executives of major U. S. companies attended a conference in Pittsburgh entitled "Resource War in 3-D" (the three D's stood for dependency, diplomacy, and defense). [18:43]

Production capacity expansion is either being seriously investigated or actually on-going. For example, Hanna, Noranda, and Anschutz mining companies are considering the possibility of reopening the cobalt mines in Blackbird, Idaho and Fredericktown, Missouri. Plans to invest in domestic cobalt refining capability, which is as essential as ore mining to the U. S. import-dependency status, are also being explored, but are quite tentative at present.[7:5] In the titanium industry expansion is actually occurring with more expected in the future. RMI Company completed a 26 percent expansion (from 15 million to 19 million pounds) in July 1980, and it could rapidly expand again by 4-,8-, or 12-million more pounds if the markets should warrant such actions. Timet Division of TMCA will expand production in 1982 to 32 million pounds (from 30 million). And Dow Chemical Company and Howmet Corporation have just recently entered the market via a joint venture. [32:20]

The Cabot Corporation, one of the world's leading suppliers of super alloys essential for the manufacture of jet engines, viewed the strategic metals and minerals markets as important enough to establish a new division, Cabot Mineral Resources, whose mandate is to concentrate purely upon questions of short and long term availability of critical minerals supplies for Cabot's operating divisions. The division's responsibilities range from traditional procurement to minerals exploration and even mine ownership. [2:2]

Research and development efforts in the areas of substitution for critical materials by newly-developed or previously-known materials and of improved production techniques show great promise in alleviating dependence on foreign sources.

Magnesium refractories, titanium, nickel, and manganese have been used successfully in different applications as acceptable substitutes for chromium. [1:12] Substitution of other available alloys in one military jet engine vane resulted in a savings of 65,000 pounds of cobalt in 1980. [26:4]

Current research whose favorable results would have a potentially monumental impact on strategic materials dependence is being done on transforming abundant iron into steel of remarkable toughness and corrosion resistance--all without the use of such strategic materials as chromium

and cobalt. The alloy, generically dubbed "super-iron", can be produced invarious ways depending on the qualities desired.

The most promising technique involves manipulating the crystalline structure of alloys made up of iron and such inexpensive substances as silicon, boron, and carbon. Called rapid quenching, or cooling, this technique literally freezes these alloys in their liquid state. Ultra-fast solidification results in novel materials so homogeneous that, like glass, they have no grain structure at all. In fact, these alloys are called metallic glass, or Metglas (a trade name of Allied Chemical). Metglass is three to four times as strong as the toughest steel alloys and up to 100 times as corrosion-resistant as the best stainless steel. The only drawback is that the metallic glasses developed so far become brittle at 400 to 700 degrees F., which presently rules them out for high temperature uses. A compromise material called microcrystalline alloys processed through metal atomization are less corrosion-resistant but are just as hard and can take much higher temperatures. The alloys, costing no more than steel alloys made with cobalt, tungsten, and molybdenum, can withstand temperatures as high as 2000 degrees Fahrenheit.

The corrosion resistance of stainless steel is also being attained, without the use of chromium, by coating ordinary steel with metallic glass and microcrystalline

alloys and by implanting into it ions of other elements such as cobalt or plentiful nitrogen. [17:71]

Additional research in the areas of powder metallurgy made possible by a technology breakthrough called rapid solidification rate (RSR), diffusion bonding techniques which permit use of lower-cost, lower performance alloys in less demanding areas of structural components, and isothermal forging and hot-isostatic pressing which allow nearer-to-net-shape forming of large forgings also hold much promise for beneficial results.

E. SUMMARY

The instability of government acquisition programs, the excessive amount of counterproductive policies and regulations, and the proliferation of government agencies impacting on private industry have all contributed to stifling growth in the strategic and critical materials industries. In fact, in some instances such as the titanium industry, production capacity actually dropped for some years.

Firms associated with the strategic materials industry have very definite views on the government's role and policies and also hold ideas on how to improve them, e.g. multiyear contracting, opening public lands to minerals exploration, and improvement of stockpile management.

Private industry, through various means such as research and development projects, industry-wide conferences, and

production capacity expansion, has taken its own initiatives to alleviate the U. S. dependence on foreign sources for strategic and critical materials.

Analysis of the information presented in this chapter plus that of the preceding four will be made in the next chapter.

VI. ANALYSIS

A. HOW STRATEGIC AND CRITICAL MATERIALS AFFECT THE ACQUISITION OF MAJOR WEAPON SYSTEMS

Virtually every mineral and even some of the non-mineral materials listed in Table 1, Appendix A, are used in the manufacture of major weapon systems. Furthermore, most of these materials cannot be replaced in the systems by substituting any other material, except possibly another strategic material. Chapter II illustrated just how extensively the manufacture of weapon systems is dependent upon strategic and critical materials. Although the illustration was confined to using just three of the ninety-three materials--chromium, cobalt, and titanium--without exception, every major weapon system is built utilizing one, two, or all three of the materials either directly or indirectly through use of superalloys or components derived from them.

It would, therefore, seem very likely that the availability of these strategic materials, their prices, and the leadtimes they command for delivery would have a direct correlative effect on the availiability, prices, and delivery times of major weapon systems. Chapter III illustrates that this correlation in fact exists.

Although inflation and other economic and political factors certainly play a role in raising the costs of weapons, the 50 percent increase in the price of chromium

in 1977, the 1978 cobalt price increase from $4-7 to $25 per pound, and the 77 percent increase in titanium prices in 1980 have also had dramatic impacts on weapons costs. For example, the price rise in cobalt alone caused price increases of $18,000 for each F-100 jet engine, $21,000 for each J-79 engine, and $12,000 for each TF-34 engine--all of which are used on front-line military aircraft.

Furthermore, although the leadtimes necessary to acquire strategic and critical materials and components made from them are not the sole causes of increasing delivery times for weapon systems, they are definitely significant contributors. In 1976, average leadtime to obtain titanium sponge was 40 weeks; in 1980, leadtime had increased to 104 weeks. Large titanium forgings, which were delivered in 70 weeks in 1978, took 180 weeks in 1980. Delivery schedules for extrusions have increased from 65 weeks to 108 weeks. And small, but absolutely critical items such as titanium bolts and fasteners underwent delivery time increases of 32 to 62 weeks and 25 to 58 weeks, respectively. The chain is continued as leadtimes for titanium landing gears have expanded from 52 to 120 weeks; F-100 engines delivery has increased from 19 to 41 months; TF-34 engines now take 39 months to be received vice 20 months in 1977. The ultimate result of the above increases is that it now takes 22 percent longer to get an operational F-15 fighter aircraft into the

defense arsenal, 34 percent longer for an A-10, and 50 percent longer for an F-16.

Notwithstanding the importance of the above facts, they pale when compared to the possibility of not being able to build major weapons at any price. Although unlikely, this possibility does exist if one imagines the scenario of total cutoff of strategic materials supplies from foreign sources. This scenario, albeit with many intricacies and details excluded, is a basis for the existence of the National Defense Stockpile--to support the U. S. economy's needs for strategic and critical materials for a period of three years in the event of supply interruption. Can the Stockpile, in its present status, accomplish that purpose? The answer is no. Over 60 percent of the line items are below established inventory goals--37 percent are below 50 percent. There is growing concern that some of the materials, transferred to the Stockpile in the 1950's, are no longer of the requisite quality. Nor are the materials being stockpiled in the proper forms--more upgraded forms requiring less production leadtime upon use are being promoted to be better.

Therefore, postulation can be made that in the event of a national emergency in which supply lines of strategic materials from foreign sources would be severed, the United States could possibly find itself without the materials necessary to manufacture the weapons for its defense arsenal.

It can, therefore, be said that strategic and critical materials affect the acquisition of major weapons systems through increased prices which decrease the number of units that can be bought with a fixed budget or force the acceptance of lower performance, less quality products, through increased leadtimes which result in obsolete units entering the arsenal, and through the possibility of the delivery of no weapons due to the unavailability of the materials necessary to build them.

B. HOW GOVERNMENT POLICIES HAVE CONTRIBUTED TO THE CURRENT SITUATION

As will be substantiated by details and examples, in the past, government's position on national interests whose satisfactory attainment depends on the availability of reasonably priced strategic and critical materials has been marked by a lack of coordinated efforts, overlapping legislation and agencies jurisdictions, and unreasonable, shortsighted policies which have stifled the related industries--there is no single national policy nor a central agency designated to formulate and administer one.

This lack of a national policy and a single point of integrative responsibility has perpetuated the existence of some 20 uncoordinated agencies administering 80 laws and has allowed conflict to flourish among those agencies. An example is those agencies whose raison d'etre is conservation of national resources and protection of the environment and

the American people, and those agencies and industries which advocate minerals exploration and development in the name of national survival.

The Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) are members of the former group. Mining and minerals processing industries, foundries, smelting companies, and forging and casting industries are examples of the latter. Following are some examples of how these opposing sides interact and how pertinent laws and regulations affect them.

As one legislative example, the Clean Air Act of 1977, whose implementation is the responsibility of the EPA, has driven up production costs for the metals industries as much as 25 percent without increasing output. And, according to industry estimates, the copper industry would have to spend $3 billion by 1985 to meet existing environmental, health, and safety regulations. Such a diversion of funds from investment in productive facilities would result in a 17 percent decline in domestic output of refined copper. Lastly, in the past decade, over 400 foundries, which fabricated products using strategic materials, have gone out of business primarily because of EPA and OSHA requirements.

The intention of Congress in the passage of the Mining and Minerals Policy Act of 1970 was to pass to the Department of the Interior the responsibility for formulating and implementing a national policy. In the opinion of Congress,

Interior had abdicated that responsibility for a decade; and their distress resulted in passage of the National Materials and Minerals Policy, Research and Development Act of 1980. Although their motives were justified and sincere and it is still too early to pass final judgment on the total value of the Act, it can be said that at present the Act has caused even more confusion over which agency has overall policy responsibility and has moved the country little closer to a unified national policy.

Instability of government procurement programs has also contributed to the current situation. It has contributed significantly to the failing health of the subcontractor tier of the defense industrial base. These same subcontractors have confessed that this instability has obligated them to charge the government 25 to 100 percent more than that billed to commercial companies.

These subcontractors, as well as prime contractors, also lament the restrictive and inflexible procurement regulations which prohibit the discretionary use of the contract type most beneficial to all concerned--the multiyear contract. Estimates have been proffered that suggest the government loses 10 to 15 percent of its annual appropriations due to lack of its use. Whether or not these figures are accurate is not of the greatest significance. What is important is the recognition that the obstacles to the use of multiyear

need to be removed so true discretionary use of it can be applied when in the best interests of all concerned.

Another plus factor for the argument of establishing a national non-fuel minerals policy along with a responsible agency is a "foreign policy not in tune with reality." Although a foreign policy based on the promotion and preservation of human rights was a penchant of the Carter Administration and is no longer in vogue in the present one, it is indicative of what can happen to the strategic materials interests when there is no central advocate to champion its cause. It seems inconceivable that sanctions in the name of human rights (although an admirable ideal) can be levied against countries vital to our supplies of irreplaceable strategic materials, and thus our national defense, when viewed from the aspect of possible consequences.

Another major area in which government's policies and actions have caused significant repercussions is in the use of the inventories of the National Defense Stockpile. The manipulations of the goal levels, the threats of market dumps of materials to depress prices, and the sale of Stockpile commodities to balance the federal budget have resulted in annoying our foreign suppliers, in keeping the Stockpile in a perpetual state of inadequacy, and in discouraging private industry investment in new or upgraded production equipment and facilities.

Lastly, a decade's lack of a realistic attitude on the use of public lands for minerals exploration and production has prevented the mining industry from making any significant inroads into eliminating U. S. dependence on foreign sources. Far from advocating a return to an irresponsible attitude on use and abuse of natural resources, this researcher firmly believes a rational compromise must be reached between legitiment concerns for preserving the environment and pragmatic needs for making use of it.

All of the above government policies have in some manner contributed to the increasing leadtimes and prices and tenuous availabilities related to strategic and critical materials. Consequently, they also have significant effects on the acquisition of major weapon systems.

C. WHAT IS BEING DONE TO IMPROVE THE SITUATION

Both the government and private industry have been taking various diverse initiatives directed at improving this country's strategic and critical materials posture.

Several Congressional subcommittees and committees are making in-depth, searching studies in this area. As examples, both Senator Harrison Schmitt's and Representative Santini's subcommittees found profound problems that directly impact on the nation's defense capability and stressed that corrective action must be taken as quickly as possible.

The Executive Branch has also shown renewed interest. President Reagan for instance has appointed the Cabinet Council

on Natural Resources and the Environment whose charter is to investigate the entire scope of the strategic and critical materials arena.

Besides the dialogue being exchanged in the studies noted above, extensive research and development efforts are being sponsored by such agencies as FEMA and the Departments of Commerce, Defense, and the Interior. Projects include such areas as the advantages of stockpiling upgraded forms of strategic materials vice ore forms, the development of new mining technology, new methods of recovering minerals from new deposits, and many more.

The government, since the inauguration of President Reagan, has also been taking steps toward improving relationships with strategically important foreign countries like South Africa by redirecting foreign policy away from one largely dictated by the desire for worldwide acceptance of America's ideal of human rights to one based on more pragmatic precepts of the economic survival and defense of the nation.

Further in the international arena, the United States is continuing to take a very active role in the Conferences on Law of the Sea in an attempt to secure a multinational treaty which will allow mining and production of the vast reserves of manganese nodules covering large areas of the ocean floor.

Lastly, FEMA is currently pushing for the adoption of several programs and measures, which through utilization of Title III of the Defense Production Act, will improve the inventory levels of the National Defense Stockpile. Meanwhile, the agency is purchasing stocks of various materials with funds appropriated for the first time since 1961.

While government has been exerting the above efforts, private industry has by no means been sitting idle. Like the government, these firms have been conducting conferences on the subject in an attempt to discover some answers; and they have been expending funds on research and development which has produced some very promising results. In addition, various companies have expanded production capacities and more are contemplating similar action. Some companies, such as Cabot Corporation, have gone as for as founding a separate division whose sole responsibility is ensuring, for its parent company, an adequate and reasonably priced supply of strategic and critical materials.

So, it can be seen that interest and concern in the area of strategic and critical materials are finally reaching a level that is generating serious discussion and efforts directed at improving the current posture of the industry and the U. S. position. But problems are still present.

VII. CONCLUSIONS AND RECOMMENDATIONS

A. WHAT MORE SHOULD BE DONE

Government officials and management in private corporations have expressed various recommendations of what more needs to be done to overcome the remaining problems. The following are those with which the researcher agrees, or those which are uniquely his, and the reasons supporting them.

From the evidence presented in this thesis, it has been substantiated that strategic and critical materials are vital and essential to the manufacture of major weapon systems. It was also shown that increases in prices and lengthening leadtimes for these materials were directly responsible for a part of the price increases and extended delivery times being experienced by virtually every major weapon system. Also shown was how these prices and leadtime increases have at least partially resulted from various governmental policies, laws and agency dictates. Therefore, it can be said that government policies regarding strategic and critical materials have affected the acquisition of major weapon systems, and that continued adequate defense capability demands improvement of government's performance.

One area begging for improvement is the proliferation of uncoordinated laws and agencies. With some exceptions,

these laws and agencies serve useful, legitimate purposes. However, redundancy, inefficiency, and failure of agencies to realize the importance of other agencies' work result in a less than optimal utilization of our nation's strategic and critical materials resources.

What is needed is a rational, clearly defined national non-fuel minerals policy administered and championed by one centrally responsible agency. With its resources lying within the Bureau of Mines, the Department of the Interior is the logical choice to be this central coordinator. Because of the confusion that has been encircling the question of which agency is in charge of national policy, it would seem that what is needed to clear the air is either a legislative mandate designating the Department of the Interior as responsible or an executive order doing the same under the auspices of the Mining and Minerals Policy Act of 1970.

Once a central responsible agency has been designated, it must then make decisions on various issues and direct work toward eliminating various problems. Following are several recommendations on what that agency should promote.

Every effort should be made to stabilize government major weapon procurement programs. Multiyear contracting would be a step in this direction. It must, however, be recognized that multiyear is not a panacea, and that before it can be used effectively, full funding requirements, the $5

million cancellation liability, and the prohibition against charging recurring costs to cancellation charges must be revised.

A major effort needs to be undertaken toward eliminating the government laws and policies and agencies which are stifling the productive efforts of the strategic and critical materials industries. The EPA and OSHA, along with the laws they implement, need to be perused to develop a compromise between what they desire regarding the environment and what the country needs to maintain its defense capability. Serious review of public lands use for minerals exploration must be made.

Other recommendations which need to be incorporated into a national policy are encouragement of the domestic mining and minerals processing industries through the liberalization of depreciation rates and tax incentives for captial equipment and facilities to be used in mining and minerals production, the imposition of tariffs and export controls, increased and less complicated use of Titles I and III of the Defense Production Act, and close scrutiny of all ramifications resulting from embargoes and sanctions against foreign suppliers of strategic materials.

The final area to be addressed is that of the Stockpile. The National Defense Stockpile is a valid concept worthy of efforts to improve its current status. Goals must be filled, although these goals will come down if domestic

production is increased. The quality of the materials currently being held needs to be carefully scrutinized; if lacking, GSA should take steps to barter them to industry for higher quality materials or, barring acceptance by any companies, dispose of them. Favorable consideration should also be given to stocking more upgraded forms of materials and less ore forms.

In addition to the National Defense Stockpile which should only be used for national defense, there should also be some sort of "economic stockpile' which can be used to smooth out supply and demand fluctuations in the strategic materials market. There was no consensus among the government officials or the corporate officers interviewed as to who should manage such a stockpile. Although the researcher believes in the efficacy of an economic stockpile, much more research is needed before it can become a reality.

B. CONCLUSIONS

Based on the above information and that presented in the previous six chapters, the following conclusions are drawn and recommendations made by the researcher.

1. The price increases and lengthening leadtimes being experienced by major weapon systems over the recent past have been caused, at least in part, by concomitant increases in prices and leadtimes for vital and essential strategic and critical materials. At the same time, the price and

leadtime increases for strategic and critical materials has been caused, in part, by government laws, policies, and agencies. There is, therefore, a correlative effect between government policies regarding strategic and critical materials and the acquisition of major weapon systems.

2. Although best suited to the task of formulating and implementing a national non-fuel minerals policy due to its resources found in the Bureau of Mines and although directed to do so by the Mining and Minerals Policy Act of 1970, the Department of the Interior has abdicated this responsibility. Thus, there is no single, coordinated national non-fuel minerals policy, nor any single agency responsible for implementing it. This lack of a coordinated policy and a central agency has led to the following problems.

a. Overlaps in agencies jursidictions, conflicts, confusion, inefficiencies, and detrimental impacts on the strategic and critical materials industries.

b. Agencies such as the EPA and OSHA have been able to implement policies injurious to the strategic and critical materials industries and responsible for lengthening leadtimes and increasing prices for major weapon systems.

c. A foreign policy that is not in tune with the economic and defense reality of the United States; one that imposes embargoes and sanctions against foreign countries who are vital to our supply of essential strategic materials and thus our national defense.

3. Management of the National Defense Stockpile, although improved, is still less than optimal and must continue on this trend of improvement.

a. Past use of the Stockpile for budgetary and other purposes outside that of national defense have caused annoyance of foreign suppliers, artificial depression of domestic prices resulting in lack of incentive to develop domestic sources of supply, low inventory levels of certain Stockpile commodities, and stifling of productive expansion.

4. There has been within the last several years a significant increase in concern regarding strategic and critical materials by government officials. This growing concern has resulted in congressional hearings; appointment of executive branch study groups; and realization that industry is being adversely affected by the proliferation of laws and regulations and agencies, the lack of public land use for mineral production, the instability of government procurement programs, and antiquated depreciation and tax rates.

5. The United States is dangerously import-dependent for strategic and critical materials on unstable foreign sources. Our national defense is thus vulnerable to disruption of those supplies for whatever reason. The domestic mining and processing industries need to be encouraged to develop the United States reserves of strategic and critical materials to eliminate or at least ameliorate this dependence.

a. This encouragement can be manifested through use of Titles I and III of the Defense Production Act, by responsible imposition of tariffs and export restrictions, and by changes to the antiquated depreciation, tax, and antitrust laws mentioned earlier.

6. An economic stockpile concept of some sort would help alleviate the effects of fluctuations in supply and demand for strategic and critical materials. Although a good concept, much more study must be given to the subject to determine who would manage it and how, and whether it would be a separate stockpile or just an adjunct to the National Defense Stockpile.

C. *RECOMMENDATIONS*

1. The President should issue an executive order designating the Department of the Interior responsible for formulating and administering a national non-fuel minerals policy. All functions related to strategic and critical materials such as research and development, must be coordinated through that agency.

2. The United States posture regarding strategic and critical materials available in case of a national emergency must be improved. This improvement must be accomplished via a two-pronged approach. First, production of domestic reserves must be increased through use of the Defense Production Act and incentives such as accelerated depreciation

methods, tax incentives, and less strict antitrust laws. Secondly, inventory goal levels for the National Defense Stockpile must be met as soon as possible. This objective can be achieved by congressional appropriation of funds to procure more foreign supplies and by guaranteed purchase programs of domestically produced materials using Defense Production Act authority and funds.

3. The concept of an economic stockpile should be pursued. Further study is required to determine how best to model and implement such a stockpile of strategic non-fuel minerals.

APPENDIX A

STOCKPILE INVENTORY [9:12-18]

Explanation of Table 1

The National Defense Stockpile total inventory as given in Table 1 excludes quantities that were sold but not shipped from depots to the purchasers. In the Statistical Supplement (available from GSA) the inventory is listed as "Total Inventory in Storage" with a separate line for "Unshipped Sales."

The Table 1 inventory quantities combine stockpile and nonstockpile grade materials, while separate lines can be found for each type in the Statistical Supplement. Some nonstockpile grade materials were acquired by transfer of government-owned surpluses after World War II or through Defense Production Act purchase programs. Other materials were of stockpile grade when acquired, but no longer qualify because of changes in industry practices. Nonstockpile grade material may vary only slightly from the stockpile grade and in some cases is temporarily credited toward goals.

For some materials where a goal deficit occurs, the excess of another form of that material is held to offset the shortage as indicated in the footnotes at the end of Table 1. The term "offset" means allocating one form of a material for an equivalent amount of another form.

Materials are grouped by "families" and a summary line for each basic family group is included. The materials have been grouped in each family according to their status as raw material, semifinished products or finished products that contain the same common ingredient. The values shown in the summary line for each family group are expressed in the basic unit common to all members of the group. In all but three cases, this basic unit is the metal equivalent for each form. There is a different conversion factor for each form because each requires different technology and incurs different conversion losses. The factors used for calculating these equivalent amounts and the calculation procedure are in Appendix B.

Market values are prices at which comparable materials are being traded, or in the absence of trading, values are estimates. They are not necessarily the amount that would be realized if the material were sold.

TABLE 1

NATIONAL DEFENSE STOCKPILE INVENTORY OF STRATEGIC AND CRITICAL MATERIALS

September 30, 1980

Commodity	Unit	1980 Goal	Inventory	Value of Inventory (Millions $)	Quantity After Crediting Offset Excess	Quantity After Crediting Offset Deficit
1. Aluminum Metal Group	**ST Al Metal**	**7,150,000**	**3,444,064**	**551.1**		**3,705,936**
Alumina	ST	0	0			
Aluminum	ST	700,000	1,733	2.4		698,267
Bauxite, Metal Grade, Jamaica Type	LDT	21,000,000	8,858,881	334.1		12,141,119
Bauxite, Metal Grade, Surinam Type	LDT	6,100,000	5,299,596	214.6		800,404
2. Aluminum Oxide, Abrasive Grain Group	**ST Ab Grain**	**638,000**	**259,124**	**124.0**		**378,876**
Aluminum Oxide, Abrasive Grain	ST	0	50,904	59.0	a	
Aluminum Oxide, Fused, Crude	ST	0	249,867	65.0	a	
Bauxite, Abrasive Grade	LCT	1,000,000	0			a
3. Antimony	**ST**	**36,000**	**40,730**	**163.7**	**4,730**	
4. Asbestos, Amosite	**ST**	**17,000**	**42,534**	**21.9**	**25,534**	
5. Asbestos, Chrysotile	**ST**	**3,000**	**9,958**	**8.9**	**6,958**	
6. Bauxite, Refractory	**LCT**	**1,400,000**	**174,599**	**34.0**		**1,225,401**
7. Beryllium Metal Group	**ST Be Metal**	**1,220**	**1,061**	**150.1**		**159**
Beryl Ore (11% BeO)	ST	18,000	17,987	18.8		13
Beryllium Copper Master Alloy	ST	7,900	7,387	67.2		513
Beryllium Metal	ST	400	229	64.1		171
8. Bismuth	**LB**	**2,200,000**	**2,081,298**	**5.2**		**118,702**
9. Cadmium	**LB**	**11,700,000**	**6,328,729**	**15.8**		**5,371,271**
10. Castor Oil (Sebacic Acid)	**LB**	**22,000,000**	**5,009,697**	**8.9**		**9,475,757**
11. Chromium, Chemical and Metallurgical Group	**ST Cr Metal**	**1,353,000**	**1,173,230**	**1,033.8**		**179,770**
Chromite, Chemical Grade Ore	SDT	675,000	242,414	14.3		6

TABLE 1

NATIONAL DEFENSE STOCKPILE INVENTORY OF STRATEGIC AND CRITICAL MATERIALS (Continued)

September 30, 1980

Commodity	Unit	1980 Goal	Inventory	Value of Inventory (Millions $)	Quantity After Crediting Offset Excess	Quantity After Crediting Offset Deficit
Chromite, Metallurgical Grade Ore	SDT	3,200,000	2,488,043	258.9		b
Chromium, Ferro, High Carbon	ST	185,000	402,696	269.5	b	
Chromium, Ferro, Low Carbon	ST	75,000	318,892	418.1	b	
Chromium, Ferro, Silicon	ST	90,000	58,355	43.6		b
Chromium, Metal	ST	20,000	3,763	29.4		b
12. Chromite, Refractory Grade Ore	**SDT**	**850,000**	**391,414**	**36.9**		**458,586**
13. Cobalt	**LB Co**	**85,400,000**	**40,802,393**	**1,020.1**		**44,597,607**
14. Columbium Group	**LB Cb Metal**	**4,850,000**	**2,510,528**	**37.7**		**2,339,472**
Columbium Carbide Powder	LB Cb	100,000	21,372	6		78,628
Columbium Concentrates	LB Cb	5,600,000	1,780,463	29.3		c
Columbium, Ferro	LB Cb	0	930,911	6.0	c	
Columbium, Metal	LB Cb	0	44,851	1.8	c	
15. Copper	**ST**	**1,000,000**	**29,048**	**65.1**		**970,952**
16. Cordage Fibers, Abaca	**LB**	**155,000,000**	**0**	**—**		**155,000,000**
17. Cordage Fibers, Sisal	**LB**	**60,000,000**	**0**	**—**		**60,000,000**
18. Diamond, Industrial Group	**KT**	**29,700,000**	**42,929,316**	**416.1**	**13,229,316**	
Diamond Dies, Small	PC	60,000	25,473	1.1		34,527
Diamond, Industrial, Crushing Bort	KT	22,000,000	23,692,782	66.1	1,692,782	
Diamond, Industrial, Stones	KT	7,700,000	19,223,798	348.9	11,523,798	
19. Feathers and Down	**LB**	**1,500,000**	**0**	**—**		**1,500,000**
20. Fluorspar, Acid Grade	**SDT**	**1,400,000**	**895,983**	**125.4**		**504,017**
21. Fluorspar, Metallurgical Grade	**SDT**	**1,700,000**	**411,738**	**40.1**		**1,288,262**
22. Graphite, Natural, Ceylon, Amorphous Lump	**ST**	**6,300**	**5,498**	**5.2**		**802**

TABLE 1

NATIONAL DEFENSE STOCKPILE INVENTORY OF STRATEGIC AND CRITICAL MATERIALS (Continued)

September 30, 1980

Commodity	Unit	1980 Goal	Inventory	Value of Inventory (Millions $)	Quantity After Crediting Offset Excess	Quantity After Crediting Offset Deficit
23. Graphite, Natural, Malagasy, Crystalline	**ST**	**20,000**	**17,911**	**11.9**		**2,089**
24. Graphite, Natural, Other than Ceylon & Malagasy	**ST**	**2,800**	**2,802**	**.5**	**2**	
25. Iodine	**LB**	**5,800,000**	**8,013,074**	**47.3**	**2,213,074**	
26. Jewel Bearings	**PC**	**120,000,000**	**68,731,890**	**61.2**		**51,268,110**
27. Lead	**ST**	**1,100,000**	**601,036**	**504.9**		**498,964**
28. Manganese, Dioxide, Battery Grade Group	**SDT**	**87,000**	**250,643**	**23.3**	**163,643**	
Manganese, Battery Grade, Natural Ore	SDT	62,000	247,632	20.3	d	
Manganese, Battery Grade, Synthetic Dioxide	SDT	25,000	3,011	3.0		d
29. Manganese, Chemical & Metallurgical Group	**ST Mn Metal**	**1,500,000**	**1,586,581**	**529.8**	**86,581**	
Manganese Ore, Chemical Grade	SDT	170,000	221,044	18.1	51,044	
Manganese Ore, Metallurgical Grade	SDT	2,700,000	3,378,713	186.2		e
Manganese, Ferro, High Carbon	ST	439,000	599,978	273.2	e	
Manganese, Ferro, Low Carbon	ST	0	0			
Manganese, Ferro Medium Carbon	ST	0	28,920	22.0	e	
Manganese, Ferro, Silicon	ST	0	23,574	11.6	e	
Manganese Metal, Electrolytic	ST	0	14,172	18.7	e	
30. Mercury	**FL**	**10,500**	**191,391**	**78.0**	**180,891**	
31. Mica Muscovite Block, Stained and Better	**LB**	**6,200,000**	**5,212,444**	**27.8**		**987,556**

TABLE 1

NATIONAL DEFENSE STOCKPILE INVENTORY OF STRATEGIC AND CRITICAL MATERIALS *(Continued)*

September 30, 1980

Commodity	Unit	1980 Goal	Inventory	Value of Inventory (*Millions $*)	Quantity After Crediting Offset Excess	Deficit
32. Mica Muscovite Film, First and Second Qualities	LB	90,000	1,274,495	14.9	1,184,495	
33. Mica Muscovite Splittings	LB	12,630,000	19,546,395	39.1	6,916,395	
34. Mica Phlogopite Block	LB	210,000	130,745	.1		79,255
35. Mica Phlogopite Splittings	LB	930,000	2,019,537	2.0	1,089,537	
36. Molybdenum Group	LB Mo	0	0	—	—	
Molybdenum Disulphide	LB Mo	0	0			
Molybdenum, Ferro	LB Mo	0	0			
37. Nickel	ST Ni+Co	200,000	0	—		200,000
38. Opium Group	AMA LB	130,000	71,303	29.6		58,697
Opium, Gum	AMA LB	0	31,795	6.7		
Opium, Salt	AMA LB	130,000	39,508	22.9		
39. Platinum Group Metals, Iridium	Tr Oz	98,000	16,991	10.2		81,009
40. Platinum Group Metals, Palladium	Tr Oz	3,000,000	1,255,003	282.4		1,744,997
41. Platinum Group Metals, Platinum	Tr Oz	1,310,000	452,640	215.0		857,360
42. Pyrethrum	LB	500,000	0	—		500,000
43. Quartz Crystals	LB	600,000	2,423,036	14.5	1,823,036	
44. Quinidine	Av Oz	10,100,000	1,800,462	7.8		8,299,538
45. Quinine	Av Oz	4,500,000	3,246,164	10.9		1,253,836
46. Rubber	LT	850,000	119,208	209.6		730,792
47. Rutile	SDT	106,000	39,186	12.7		66,814

TABLE 1

NATIONAL DEFENSE STOCKPILE INVENTORY OF STRATEGIC AND CRITICAL MATERIALS (Continued)

September 30, 1980

Commodity	Unit	1980 Goal	Inventory	Value of Inventory (Millions $)	Quantity After Crediting Offset Excess	Deficit
48. Saphire and Ruby	KT	0	16,305,502	.2	16,305,502	
49. Silicon Carbide, Crude	ST	29,000	80,548	36.2	51,548	
50. Silver, Fine	Tr Oz	0	139,500,000	3,113.6	139,500,000	
51. Talc, Steatite Block and Lump	ST	28	1,092	.4	1,064	
52. Tantalum Group	LB Ta Metal	7,160,000	2,391,940	397.2		4,768,060
Tantalum, Carbide Powder	LB Ta	0	28,688	5.0	g	
Tantalum Metal	LB Ta	0	201,133	40.2	g	
Tantalum Minerals	LB Ta	8,400,000	2,551,302	352.0		g
53. Thorium Nitrate	LB	600,000	7,146,312	19.7	6,546,312	
54. Tin	LT	42,000	200,472	3,585.1	158,472	
55. Titanium Sponge	ST	195,000	32,331	431.8		162,669
56. Tungsten Group	LB W Metal	50,666,000	81,883,096	876.1	31,217,096	
Tungsten Carbide Powder	LB W	2,000,000	2,032,942	29.2	h	
Tungsten, Ferro	LB W	0	2,025,361	24.7	h	
Tungsten, Metal Powder	LB W	1,600,000	1,898,911	26.4	h	
Tungsten Ores & Concentrates	LB W	55,450,000	89,219,603	795.8	h	
57. Vanadium Group	ST V Metal	8,700	541	5.9		8,159
Vanadium, Ferro	ST V	1,000	0	-		1,000
Vanadium Pentoxide	ST V	7,700	541	5.9		7,159
58. Vegetable Tannin Extract, Chestnut	LT	5,000	16,894	9.4	11,894	
59. Vegetable Tannin Extract, Quebracho	LT	28,000	144,828	81.9	116,828	
60. Vegetable Tannin Extract, Wattle	LT	15,000	16,398	9.2	1,398	
61. Zinc	ST	1,425,000	375,970	282.9		1,049,030

[1]Sebacic Acid inventory is credited toward Castor Oil goal at a rate of 2.5 to 1.

OFFSETS

a. **Aluminum Oxide, Fused Crude:** hold 249,864 ST of fused crude as offset against 208,220 ST of aluminum oxide, abrasive grain.

b. **Chromium Group, Chemical and Metallurgical Grades:** metallurgical grade ore goal is 3,200,000 SDT of specification grade; inventory 1,956,824 SDT, shortfall 1,243,176 SDT

(1) Hold 217,695 ST of Fe Cr high carbon against shortfall of 544,238 SDT of specification grade ore.
(2) Hold 243,892 ST of Fe Cr low carbon against 609,730 SDT of specification grade ore.
(3) Hold 89,208 SDT of non-specification grade metallurgical ore against the balance of the 89,208 SDT specification grade ore shortfall.
(4) Hold 47,466 SDT of non-specification grade metallurgical ore against a shortfall of 31,644 ST of Fe Cr Si.
(5) Hold 56,830 SDT of non-specification grade metallurgical ore against a shortfall of 16,237 ST of chromium metal.
(6) Hold 337,715 SDT of non-specification grade metallurgical ore against 337,715 SDT of chemical grade ore shortfall

c. **Columbium Group:**

(1) Hold 930,911 pounds Cb as Fe Cb against 1,095,189 pounds Cb as concentrates.
(2) Hold 44,851 lb Cb as Cb metal against 52,766 lb Cb as concentrates.

d. **Manganese, Dioxide, Battery Grade Group:**

Hold 21,989 SDT of managanese, battery grade, natural ore against a shortfall of 21,989 SDT of manganese, battery grade, synthetic dioxide.

e. **Manganese Group, Chemical and Metallurgical Grades:** metallurgical grade ore goal is 2,700,000 SDT; inventory 2,409,377 SDT; shortfall 290,623 SDT of stockpile grade ore.

(1) Hold 14,172 ST of Mn metal against 35,430 SDT of metallurgical ore.
(2) Hold 23,574 ST of Fe Mn Si against 42,433 SDT of metallurgical ore.
(3) Hold 28,921 ST of Fe Mn medium carbon against 57,842 SDT of metallurgical ore.
(4) Hold 77,460 ST of Fe Mn high carbon against 154,920 SDT of metallurgical ore.
(5) Hold remaining 83,518 ST of Fe Mn high carbon against reduction of ore value in desired inventory mix.

f. **Opium:** Hold 31,795 AMA lb of opium gum against 31,795 AMA lb of opium salt goal.

g. **Tantalum Group:**

(1) Hold 201,133 lb Ta as Ta metal against 237,337 lb Ta as concentrates.
(2) Hold 28,688 lb Ta as Ta C against 33,852 lb Ta as concentrates.

h. **Tungsten Group:**

(1) WC powder goal is 2,000,000 lb W; stockpile grade inventory 1,921,167 lb W; shortfall 78,833 lb W. Hold 111,775 lb W as non-specification grade WC to offset 78,243 lb W as WC specification grade (assume 70% recovery of usable W).

(2) W metal powder goal is 1,600,000 lb W; inventory stockpile grade 1,566,964 lb W, shortfall 33,036 lb W. Non-stockpile grade W metal powder inventory is 331,947 lb W. Assume 70% recovery as usable material, then 331,947 x .70=232,363 lb W. Hold 47, 194 lb W as non-specification grade powder to offset shortfall of 33,036 stockpile grade W powder

(3) Hold balance of non-stockpile grade W powder 232,363 - 33,036 = 199,327 lb W as powder against 234,209 lbs W as concentrate.

(4) Hold 840,752 lbs W as Fe W stockpile grade against 987,884 lb W as concentrate. Hold 1,184,609 lb W nonstockpile grade Fe W at 70 percent recoverable against 974,341 lb W concentrate

Abbreviations

AMA Lb	- Anhydrous Morphine Alkaloid (Pounds)	LCT	- Long Calcined Ton
AvOz	- Avoirdupois Ounce	LDT	- Long Dry Ton
Fl	- Flask (76-Pound)	LT	- Long Ton
KT	- Carat	PC	- Piece
LB	- Pound	SDT	- Short Dry Ton
LB Cb	- Pounds of Contained Columbium	ST	- Short Ton
LB Co	- Pounds of Contained Cobalt	ST Ni+Co	- Short Tons of Contained Nickel plus Cobalt
LB Mo	- Pounds of Contained Molybdenum	ST V	- Short Tons of Contained Vanadium
LB Ta	- Pounds of Contained Tantalum	TrOz	- Troy Ounces
LB W	- Pounds of Contained Tungsten		

APPENDIX B

CALCULATION PROCEDURE FOR FAMILY GROUPINGS OF MATERIALS [9:27-30]

The following example is designed to help the reader perform and understand the conversions and calculations used in preparing summary lines for basic family groupings. The purpose in using basic units for each of the families or groups of materials is to place the content of the primary material into a common denominator for easier comparison.

In time of emergency, there would be a need for a mix of various forms of each metal element. The stockpile goal for a metal is a mix of products at various stages of upgrading. The goal is caluclated by examining expected wartime requirements, availability, and domestic capacity to produce each of the upgraded forms.

There is a different factor for converting each of the forms into a common denominator, usually the basic metal equivalent. The conversion factors are different because process conversion losses vary. The calculations and conversions used for beryllium metal group are shown as an example. The figures used do not reflect the current inventory quantities.

The beryllium metal group has a surplus of beryl ore (11%BeO) and shortaflls of Beryllium copper master alloy (BCMA) and

beryllium metal. Beryl ore is a raw material used in producing the other two products. The surplus of beryl ore is used to offset the shortfall of the upgraded forms, but in different proportions for each product because of the product composition and the accompanying processing loss.

COMMODITY	UNIT	GOAL	TOTAL INVENTORY	EXCESS	DEFICIT
Beryllium Metal....	ST BE METAL	1,563	1,061		502
Beryl Ore..................	ST	0	17,986	0	0
Beryllium Copper Master Alloy..................	ST	16,710	7,387	0	0
Beryllium Metal...........	ST	895	229	0	502

PROCEDURE

1. Note that the available surplus of beryl ore is 17,986 ST.

2. Calculate the shortfall of BCMA.

16,710 ST Goal minus 7,387 ST inventory equals 9,323 ST shortfall.

3. Calculate the quantity of beryl ore required to offset 9,323 ST of BCMA.

9,323 ST BCMA times 1.3 equals 12,120 ST beryl ore.

4. Calculate the basic unit equivalent of the 9,323 ST of BCMA.

9,323 ST BCMA times 0.04 equals 373 ST beryllium metal.

5. Subtract the quantity of ore calculated to offset the shortfall of BCMA (3 above) from the total quantity of ore available (1 above).

17,986 ST ore minus 12,120 ST ore equals 5,866 ST of ore remaining.

6. The remaining quantity of surplus ore not used to cover the BCMA shortfall can now be used to offset part of the shortfall of beryllium metal. Convert the remaining ore to beryllium metal.

5,866 ST ore times 0.02801 equals 164 ST beryllium metal.

7. The total surplus beryl ore has been converted to the two upgraded forms, BCMA and beryllium metal, to cover the shortfall of these forms. The balance of excess ore is now zero.

12,120 ST ore converted to 9,323 ST BCMA

5,866 ST ore converted to 164 ST beryllium metal

Total 17,986 ST ore converted to BCMA and beryllium metal.

In converting the ore to beryllium metal, only one conversion was required. To convert the BCMA to the basic unit, i.e., beryllium metal, an additional conversion is needed. BCMA contains a nominal 4 percent beryllium metal. To convert the BCMA to beryllium metal, simply multiply 9,323 BCMA ST by .04 which equals 373 ST of beryllium metal.

The conversion to basic units is now complete.

12,120 ST ore to BCMA to beryllium metal equals 373 ST.

5,866 ST ore to beryllium metal equals 164 ST.

Total of 17,986 ST ore equals 537 ST beryllium metal.

EXAMPLE - BERYLLIUM METAL (ST)

	Beryl Ore (11% BeO)	Equivalent Basic Units
Excess to Goal	17,986	
Converted to Offset BCMA Shortfall (9,323 X 1.3)	-12,120	373
Balance	5,866	
Converted to Offset Beryllium Metal Shortfall (5,866 X 0.02801)	-5,866	164
Balance of Excess	0	
Total of Basic Units Offset		537

The balance of the family totals is shown in the table. Each of the forms of beryllium material has been converted to the basic beryllium metal units for easy subtraction and addition. Surplus material is shown as positive, shortfalls are shown as negative. The final balance for the family is 1,061 ST in inventory, 1,563 ST needed for the goal, leaving a shortfall of 502 ST beryllium metal.

Balance of Family Totals in Basic Units

	Inventory	Goal	Excess (+) Deficit (-)
Beryl Ore (11% BeO)	537	0	537
BCMA	295	668	-373
Beryllium Metal	229	895	-666
Total	1,061	1,563	-502

Factors Used for Converting Materials Into Family Groups

Materials	Unit	Multiple Factor	Basic Family Unit
Alumina	ST	0.518	Metal Equivalent, Aluminum
Aluminum Oxide, Fused, Crude	ST	0.85	Aluminum Oxide, Abrasive Grain
Bauxite, Abrasive Grade[1]	LCT	0.641	Aluminum Oxide, Abrasive Grain S.T.
Bauxite, Metal Grade, Jamaica Type	ST	0.231	Metal Equivalent, Aluminum
Bauxite, Metal Grade, Surinam Type	ST	0.264	Metal Equivalent, Aluminum
Beryl Ore (11% BeO)	ST	0.028	Metal Equivalent, Beryllium
Beryllium Copper Master Alloy (4% Be)	ST	0.04	Metal Equivalent, Beryllium
Chromite, Chemical Grade Ore	ST	0.286	Metal Equivalent, Chromium
Chromite, Metallurgical Grade Ore	ST	0.286	Metal Equivalent, Chromium
Chromium, Ferro, High Carbon	ST	0.714	Metal Equivalent, Chromium
Chromium, Ferro, Low Carbon	ST	0.714	Metal Equivalent, Chromium
Chromium, Ferro, Silicon	ST	0.429	Metal Equivalent, Chromium
Columbium, Concentrates	LB	0.850	Metal Equivalent, Columbium
Diamond Dies, Small	PC	0.50	Carat
Manganese, Dioxide, Battery Grade	SDT	1.000	Manganese, Dioxide, Battery Grade, Synthetic
Manganese, Chemical Grade	ST	0.400	Metal Equivalent, Manganese
Manganese, Metallurgical Grade	ST	0.400	Metal Equivalent, Manganese
Manganese, Ferro, High Carbon	ST	0.800	Metal Equivalent, Manganese
Manganese, Ferro, Medium Carbon	ST	0.800	Metal Equivalent, Manganese
Manganese, Ferro Silicon	ST	0.720	Metal Equivalent, Manganese
Opium Gum	AMA LB	1.000	Opium Salts
Tantalum Minerals	LB	0.85	Metal Equivalent, Tantalum
Tungsten Ores and Concentrates	LB	0.851	Metal Equivalent, Tungsten

[1]New conversion factor furnished by Bureau of Mines, Department of the Interior

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